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AD829742

NICKEL BASE ALLOYS

ALLOY 718

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PROCESSES AND PROPERTIES HANDBOOK

DMIC

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1. To collect, store, and disseminate technical information on the current status of research and development of the above materials.

2. To supplement established Service activities in providing technical advisory services to producers, melters, and fabricators of the above materials, and to designers and fabricators of military equipment containing these materials.

3. To assist the Government agencies and their contractors in developing technical data required for preparation of specifications for the above materials.

4. On assignment, to conduct surveys, or laboratory research investigations, mainly of a short-range nature, as required, to ascertain causes of troubles encountered by fabricators, or to fill minor gaps in established research programs.

Contract No. AF 33(615)-3408

Roger J. Runck

Roger J. Runck
Director

Notices

NICKEL BASE ALLOYS

ALLOY 718

H. J. Wagner, R. S. Burns, T. E. Carroll, and R. C. Simon*

ABSTRACT

The DMIC Handbook on Alloy 718 is a compilation of available data and information covering the metallurgy, manufacturing, applications, and mechanical properties of this nickel-base heat-resistant alloy. Much of the textual matter has been condensed from reports and literature received from both the producers and the users of this alloy and covers subjects such as melting, forming, welding, metallography, and others of interest to the user. Mechanical properties are presented for each of the product forms and conditions in which this alloy is used and both original and digested data are included for tensile, fatigue, creep-rupture, and other properties.

*Mr. Wagner is Chief of the Specialty Alloys Division; Messrs. Burns and Carroll are Information Specialists, and Mr. Simon is an Information Analyst, in the Information Operations Division, Battelle Columbus Laboratories, Columbus, Ohio.

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INTRODUCTION

Alloy 718 is a wrought nickel-base alloy which was initially intended for use up to about 1300 F. It differs from the 1500 to 1800 F nickel alloys in that (1) columbium is substituted for much of the aluminum and titanium and (2) 19 percent iron is substituted for most of the molybdenum and all of the cobalt. The effect of these differences is to reduce the high-temperature strength with a corresponding increase in weldability.

A variety of heat treatments and compositional variations have been used to achieve specific optimum properties such as:

1. Short-time high-temperature tensile strength
2. Stress-rupture strength
3. Notch tensile strength
4. Fatigue strength
5. Weldability.

In addition, it was discovered that, when properly processed, Alloy 718 has useful cryogenic properties down to -423 F.

Variations in heat treatment and composition and other physical-metallurgy details of Alloy 718 are fully discussed in DMIC Report 217 by Wagner and Hall.

Since DMIC issued Report 217, a considerable quantity of property data on Alloy 718 have been extracted and tabulated. The primary purpose of this Handbook is to make these data available for general dissemination. Much of the information on physical metallurgy was taken from Report 217, and condensed and repackaged to fit the Handbook format.

I. METALLURGY

Melting
Casting
Metalworking
Metallography
Corrosion
Stress Corrosion
Physical Metallurgy

MELTING

Alloy 718 is usually vacuum melted. Procedures employed include (a) induction melting in air followed by consumable-electrode vacuum-arc remelting, or (b) vacuum-induction melting (sometimes followed by consumable-electrode or vacuum-induction remelting). Vacuum melting prevents uncontrolled losses of easily oxidized elements such as Ti and Al and removes gaseous impurities, thereby permitting stricter control of final composition. All of these factors result in more consistent properties than can be obtained by air melting. Consistently better 100-hour creep-rupture strength is usually obtained over the entire temperature range of importance by employing vacuum melting techniques.

Consumable-electrode vacuum-arc melting volatilizes impurities and also breaks down and disperses nonmetallic inclusions. Segregation and unsoundness at the center of the ingot are reduced, resulting in improved hot-working characteristics, particularly when vacuum-induction-melted ingots are employed as electrodes for remelting by the consumable-electrode vacuum-arc process.

Ref: * 62553, 66882

CASTING

Although Alloy 718 is used primarily in wrought forms, the alloy is also used in the form of castings. The composition is the same as that of the wrought alloy, and the alloy is usually vacuum melted. Its weldability makes it useful in the construction of cast assemblies such as jet-engine frames.

Alloy 718 is one of a number of super-alloys for which precision casting methods are currently under study. The objective of an Air Force-sponsored program at the American Brake Shoe Company is to precision cast a full-scale jet-engine turbine disc and a full-scale aircraft fin beam.

Ref: 62553, 66882, 67431, Preliminary information reported by American Brake Shoe Company, Mahwah, New Jersey, under an Air Force Contract.

METALWORKING

Alloy 718 is worked in much the same manner as other wrought nickel-base alloys. The following sections, covering forging, rolling, extrusion, and form-rolling are generally applicable to all wrought nickel-base alloys.

Forging

Nickel-base alloys are more difficult to forge than are steels. They require more care during initial breakdown (because of lesser ductility), they require higher pressures (up to twice those for steels), and their hot-working temperature range is narrower than that for steels. In addition, nickel-base alloys are damaged by contamination with sulfur.

As for other difficult-to-forge materials, the initial forging operations on nickel-base alloys are made up of light reductions and frequent reheating. This precaution is required until the coarse, as-cast grain structure has been broken up and the alloy gains some degree of toughness. Subsequent working permits the use of greater pressures and greater reduction between reheats.

Control of forging temperature is very important. The upper end of the forging range, around 2200 F, is limited by incipient melting ("hot-shortness") above this temperature. The lower end, around 1600 F, is just above the temperature range at which precipitation hardening occurs. During initial forging, the temperature should be maintained in the upper portion of the 1600-2200 F range to avoid cracking of the ingot, and frequent reheating is required. After the as-cast structure has been broken up, the workpiece temperature may be allowed to drop to 1600 F before reheating. The finish temperature for the last forging pass should be near the lower end of the forging range. During the intermediate stages of forging, reductions between heats should exceed 10 percent, in order to produce a fine wrought structure. The reduction following the last reheat should range between about 15 and 30 percent. Finishing at too low a temperature or with too little reduction leads to undesirable grain growth during subsequent heat-treating operations.

Nickel-base alloys are damaged by contamination with sulfur. Some furnaces contain sulfur-rich scale from previous heating cycles or use reducing atmospheres with enough sulfur to be harmful. The recommended practice is to support the billet or preform on clean brick or a plate of a heat-resistant alloy and to use natural gases or low-sulfur oils as furnace fuels. Slightly oxidizing conditions are recommended to reduce sulfur pickup from furnace atmospheres.

During forging of nickel-base alloys, a lubricant is necessary between the part and die to reduce their natural tendency to seize and gall. Typically with steels, the natural oxide formed upon heating serves as a parting agent; however, with the oxidation-resistant nickel-base alloys, a parting agent must be introduced mechanically. Lubricants and parting agents containing sulfur are

*References are listed in the Appendix.

undesirable. The most commonly used lubricants are mixtures of graphite and oil. Other materials that have been used with varying degrees of success are glass, mica, sawdust, and asbestos. These materials also help to minimize the chilling effect of cold dies.

Rolling

The starting billets for hot rolling include forged slabs for flat products and forged rounds, squares, and octagons for rods, bars, and shapes. These billets require careful surface conditioning (grinding or machining) before the start of rolling and frequently between rolling passes to minimize the initiation and growth of surface flaws.

Plate down to 3/8-inch thick is usually hot rolled on three-high hand mills. In the early stages, cross rolling may be utilized to obtain the desired width and to reduce directionality in the finished product. Plate intended for rerolling is then pickled and shot blasted to produce a clean surface.

Rolling of sheet down to about 0.045-inch thickness is done either hot or cold on two-high mills. Further reduction is done cold. Cold rolling enhances the mechanical properties, improves surface finish, and permits closer control of sheet thickness. Sizes down to 0.008 or 0.010-inch thickness, with widths up to 36 inches, are rolled cold on a Sendzimir mill.

Typical fabrication schedules for the production of hot-finished bar and rod products involve hot rolling of forged bars to 2-1/4-inch gothics on a 24-inch mill, followed by surface conditioning and further hot rolling on a 10-inch mill, down to 5/16-inch rod. Rod intended for later cold drawing into wire is usually coiled at this size.

Hot-rolled sheet and plate are generally heat treated after rolling, then descaled in a hot caustic bath. After being descaled, they are pickled in a hot, strong acid to provide a smooth, bright finish. Plate is flattened by roller leveling, then sheared to finish size. Sheet products are stretch-straightened before being cut to size. Hot-finished bar products are generally centerless ground after heat treating and straightening. Cold-drawing stock is heat-treated, descaled, and pickled.

Extrusion

Hot extrusion is employed for the production of long sections from machine-turned ingots or forgings. All extruders employ the Sejournet glass process, using procedures similar to those developed for extruding steel. Besides providing effective lubrication, glass serves as an insulator between the tools and the hot billet during extrusion. Excessive overheating of tools does not occur, tool life is increased, and die costs are reduced.

The key to the successful extrusion of nickel-base alloys is accurate, close control of hot-working temperature. Thus, transfer times between the furnace and the extrusion press must be minimized to avoid heat loss. Also, the speed of extrusion must be controlled so that overheating does not result from the heat of deformation that is generated during extrusion.

Whenever possible, the extruded product is quenched after extrusion to remove any adhering glass. Some untwisting or straightening may be required. The extrusion process has been used extensively in the production of seamless tubing from nickel-base alloys. Simple shapes, such as engine rings, have been extruded from a variety of nickel-base alloys.

Work is currently being done by TRW Inc., to develop a technology for the extrusion of superalloys to structural shapes; Alloy 718 is included among the materials being studied. The program is designed to define the process limits for the extrusion of superalloy shapes from cast ingots and to provide an economic appraisal of the process developed. A ring flange used in the outer-motor-case combustion section of a jet engine was selected as the part for the extrusion-process development.

Ref: 62551, 66882, Preliminary information reported by TRW, Inc., Cleveland. Ohio, under an Air Force Contract

Cold Drawing

Nickel-base alloys can be cold drawn into rod, wire, and tubular products. The starting products for the above are annealed, descaled, and pickled bars, rods, and extruded tube hollows.

The larger sizes are finished on a standard drawbench. Smaller sizes of rod and large-diameter wire are drawn on revolving bull blocks. Very fine wire, down to 0.001-inch diameter, is produced on high-speed, multiple-die drawing machines, using diamond dies submerged in oil.

A variety of lubricants are utilized in drawing. During early stages, lead and copper coatings are also used frequently.

In wire drawing, reductions as high as 40 percent can be taken before intermediate annealing is required. To prevent scaling, the wire is annealed in a "bright" annealing furnace, utilizing an atmosphere of cracked ammonia and hydrogen.

Form Rolling

Engelhard Industries is presently engaged in a program to develop and prove economical manufacturing techniques for form-rolling close-tolerance shapes from superalloys. Alloy 718 is one of the alloys being studied. Configurations in which these alloys are being formed include E, T, and L sections.

Ref: 66076, Preliminary information reported by Engelhard Industries, Inc., Attleboro, Massachusetts, under an Air Force Contract.

METALLOGRAPHY

Sample Preparation

The preparation of samples for metallographic examination follows standard techniques. For macroexamination, grinding on a surface grinder or coarse emery belt is usually adequate. Etching involves immersion in, or flooding with, Lepito's etchant or hydrochloric acid-peroxide etchant (see below). Macroetching is accelerated by preheating the sample in hot water before etching.

Preparation for microexamination requires careful polishing with progressively finer grits, usually with final polishing on a microcloth- or duracloth-covered wheel using a water suspension of gamma alumina. After the polishing, the surface is etched electrolytically with chromic acid for grain-boundary examination.

Ref: 64273

Microstructure

The microstructure of Alloy 718 is quite complex and is influenced highly by heat treatment and composition.

Two features of the as-cast structure can be retained in the wrought alloy, and they have a strong influence on the resulting mechanical properties. The typical dendritic structure of the as-cast ingot can be broken up through proper hot working. A Laves phase appears to be related to alloy composition. It has been identified with the appearance of "freckles" in the as-wrought matrix and is found to be detrimental to yield strength and ductility. The Laves phase is isomorphous with Fe_2Ti.

The matrix of wrought Alloy 718 is a face-centered cubic structure. Two phases are subject to precipitation during aging, dependent on the aging temperature and time. The preferred precipitate, called "gamma prime", is formed on aging at 1300 to 1400 F. This phase is a metastable body-centered tetragonal (Ni_3V) structure corresponding to Ni_3(Cb, Mo, Al, Ti). Overaging, or aging at higher temperatures, causes the transformation of this phase to a more stable orthorhombic (Ni_3Cb) phase.

The optimum precipitation of the preferred gamma-prime constituent is accomplished by aging for a short time (8 to 10 hours) at 1300 to 1400 F, followed by subsequent aging at lower temperatures.

Etching

Etchant	Composition(a)	Remarks
Lepito's	15 grams $(NH_4)SO_4$ in 75 ml H_2O 250 grams $FeCl_3$ in 100 ml HCl Mix and add 30 ml HNO_3	Etching time 30-120 seconds. Macroetch for general surface condition and weld structure.
Peroxide-Hydrochloric	H_2O_2 (30%) -- 1 part HCl 2 parts H_2O 3 parts	Must be freshly mixed. Use hot water to speed reaction. Any stains formed may be removed with 50% HNO_3. Macroetch for revealing grain structure.
Chromic acid	CrO_3 -- 5 grams H_2O 100 ml	Electrolytic microetch for grain boundaries. Use 0.2 to 0.5 amp/sq cm current for 15 to 30 seconds. Make specimen anode with a platinum or Inconel 600 cathode.

(a) Use concentrated acids.

That is, to obtain maximum strengthening it is necessary to precipitate as much gamma prime as possible without transforming to the orthorhombic Ni_3Cb phase. Thus, double aging is required.

The individual gamma-prime particles are disc-shaped and lie on the {100} planes of the matrix, with their coaxes perpendicular to these planes. The following lattice constants are reported for the gamma-prime phase, for material aged at 1400 F for 10 hours, furnace cooled to 1200 F, and aged an additional 8 hours:

a_o - 3.624 Angstrom units

c_o - 7.406 Angstrom units

Ref: 61368

CORROSION

Alloy 718 was considered a candidate material for an application involving piping of hot, flowing, nitrogen tetroxide (N_2O_4). Tests by the Aerojet-General Corporation determined that Alloy 718 showed no general corrosion in the presence of N_2O_4; however, the material did show an intergranular corrosion attack, as illustrated by photomicrographs in Aerojet-General Report No. DVR 64-365.

Ref: DMIC 59644

STRESS CORROSION

Alloy 718 (aged) specimens were subjected to a series of tests to determine their susceptibility to stress corrosion. Results showed that this alloy was immune to stress corrosion when under the following testing conditions:

(1) Alternate immersion (1000-hr duration) at 90 percent TYS in synthetic seawater

(2) Salt spray (5 percent concentration, 1000-hr duration) at 90 percent TYS of unnotched specimens

(3) Alternate immersion (500-hr duration) in synthetic seawater at 80 percent of notched tensile strength of precracked specimens that had been braze-cycle heat treated, then welded (precrack located in center of weld, normal to applied load).

Ref: DMIC 57117

PHYSICAL METALLURGY

Strengthening Mechanism

The crystallographic nature of the gamma-prime constituent and its role in strengthening Alloy 718 have been studied recently by Cometto. The following summarizes his findings.

Gamma prime, as its name implies, is similar in many ways to the face-centered cubic (gamma) matrix from which it forms. The only difference, in fact, is that gamma prime more nearly approaches the stoichiometric ratio A_3B, resulting in ordering of the atomic positions and a slight distortion of the lattice.

The A_3B-type intermetallic compounds can be classified according to the way the atoms are ordered. The type A layers can occur in four different stacking sequences, and Type B layers in two different stacking sequences, giving six different types of crystal structure or families of compounds. Table 1 shows these compound types and the corresponding nickel intermetallic compounds. It was found that Alloy 718 precipitates a metastable gamma-prime phase based on the Ni_3Cb composition, but with a body-centered tetragonal Ni_3V structure.

Table 1. Stacking Arrangements in Close-Packed Ordered A_3B Structures

Structure Type	Nickel Compound	Layer Type	Stacking Sequence
Cu_3Au	Ni_3Al	A	abcabc ...
Ni_3Ti	Ni_3Ti	A	abacabac ...
Cd_3Mg	--	A	abab ...
Al_3Pu	--	A	abcacbabcacb ...
Cu_3Ti	Ni_3Cb	B	abab* ...
Al_3Ti	Ni_3V	B	abcdef* ...

*Neglects slight distortion.

The atoms of the Ni_3Al and Ni_3V compounds occupy essentially the same lattice sites as the atoms in the gamma solid solution. On the other hand, compounds such as Ni_3Ti (hexagonal structure) and Ni_3Cb (orthorhombic Cu_3Ti structure) require a complete rearrangement of atom sites as well as composition changes in order to precipitate from a face-centered cubic matrix.

Cometto's analysis has shed considerable light on the gamma-prime strengthening mechanism in Alloy 718. It can be used to explain why the double-aging treatment results in higher strength than the single aging. Apparently, to get maximum strengthening, it is necessary to precipitate as much gamma prime as possible, without overaging; that is, without transforming from the body-centered tetragonal gamma prime to the orthorhombic Ni_3Cb. High temperatures and long times favor the latter.

Ref: 8

II. MANUFACTURING PROCESSES

- Machining
- Forming
    - General
    - Dimpling
- Heat Treating
- Cleaning
- Coating
- Joining
    - TIG Welding
    - Electron Beam Welding
    - Resistance Welding
    - Brazing
    - Adhesive Bonding
- Surface Finishing

MACHINING

Machining of Alloy 718 can be accomplished readily in either the annealed on age-hardened condition. The alloy will give a slightly longer tool life in the annealed condition. Better chip action on breaker tools and a better finish can be obtained when the alloy is in the age-hardened condition.

Table 1 lists the recommended speeds for machining the alloy with high-speed-steel tools. Table 2 presents typical lathe-turning tool dimensions. In general, the tooling and procedures used in machining Alloy 718 are similar to those used for Inconel X-750.

The Air Force Machinability Data Center, located at Metcut Research Associates, Cincinnati, Ohio, can be contacted for more specific information on the machining of Alloy 718.

Reference 62548 presents a good state-of-the-art summary on the machining of nickel-base alloys.

Table 1. Speeds (FPM) for Machining with H.S.S. Tools

Turning(a,b)	Drilling(c)	Reaming(d)	Milling(e)	Threading and Tapping
15-20	15-20	7-14	15-20	5-8

(a) Use roughing feeds of 0.010 to 0.015 inch per revolution (i.p.r.).
Finishing feeds are governed by desired finish.
(b) Operate at 60 to 100 feet per minute with cemented carbide tools with feeds of 0.005 to 0.015 i.p.r. Grade C-2 tools are suitable.
(c) Use feeds proportional to drill diameter
1/16 to 1/4 in. dia. ------0.0005 to 0.002 i.p.r.
1/4 to 3/4 in. dia. ------0.002 to 0.004 i.p.r.
3/4 to 2 in. dia. ------0.004 to 0.006 i.p.r.
(d) Reaming feeds are about three times the feed used for a drill of the same size.
(e) Use a feed of 0.003 to 0.004 inch per tooth.

FORMING

Nickel-base alloys have been fabricated both by primary and secondary forming techniques that are similar to those used for the forming of stainless steels. Methods currently employed for primary fabrication of these alloys include rolling, extrusion, forging, and drawing of tube, rod, and wire. Secondary metal-forming operations are those processes that produce finished or semi-finished parts from sheet, bar, or tubing. The room-temperature ductility of most nickel-base alloys compares with that of stainless steels, and secondary working can usually be carried out with conventional processing techniques. These techniques include the following: brake bending, deep drawing, spinning and shear forming, drop-hammer forming, trapped-rubber forming, stretch forming, tube forming, roll forming and bending, dimpling, joggling, blanking, and sizing. Most nickel-base alloys can be worked at both room and elevated temperatures. The hot-working temperatures are generally higher than those used for steel because the materials retain their strengths to higher temperatures. Reference 62551 presents an excellent state-of-the-art summary of deformation processing of nickel-base alloys.

At the present, comprehensive information on the primary and secondary forming characteristics of Alloy 718 is not readily available. However, total-elongation, uniform-elongation, and bend tests, conducted by McDonnell Aircraft Corp., indicate that the alloy possesses good formability characteristics in the annealed condition. Guerin rubber-forming and impact rubber-forming tests, also conducted by McDonnell, have indicated that in the annealed condition Alloy 718 is readily formable using standard production rubber-forming techniques. Very little restriking and hand working would be required to produce parts to production tolerances. Typical results of the forming tests are presented in Table 3.

Minimum bend radii of 0.031 inch and 0.047 inch were obtained for 0.048-inch, annealed sheet specimens bent perpendicular to and parallel to the rolling direction of the sheet, respectively. The types of failures normally experienced in sheet-forming processes are shown in Table 4.

McDonnell Aircraft Corp. has also conducted tests to determine the room-temperature dimpling characteristics of aged 0.045-inch Alloy 718. The dimpling operations were conducted per PS 19015 to determine if the material could be dimpled for 5/32 Hi-Shear rivets and 1/4-inch standard screws. It was determined that adequate dimpling could not be performed at room temperature and that elevated temperatures would be required to obtain dimples of acceptable quality for the sheet-thickness, fastener-size combinations evaluated.

Ref: 61947, 62551, 56832

Dimpling

Limited data on the dimpling of Alloy 718 are recorded in a report by the McDonnell Aircraft Corporation. This report states that attempts to form dimples in 0.043-inch-thick Alloy 718 sheet for 0.250-inch-diameter standard screws and 0.156-inch Hi-Shear rivets were unsuccessful owing to circumferential tension cracks and excessive internal shear flow.

The elongation characteristics of Alloy 718 in the STA condition are similar to Rene 41

Table 2. Grind for Typical Lathe Turning Tool

	High-Speed Steel	Cemented Carbide
Back Rake Angle	8° to 10°	0° to 8° Positive
Side Rake Angle	10° to 20°	8° Positive
End Relief Angle	7°	5° to 7° (P)[a] 8° to 10° (S)
Side Relief Angle	7°	5° to 7° (P) 8° to 10° (S)
End Cutting Edge Angle	8° to 10°	8° to 10°
Side Cutting Edge Angle	15° to 30°	15° to 30°
Nose Radius	1/32 in.	0.010 to 0.032 in.

(a) (P) Primary
(S) Secondary

General notes:

Grind drills to 130 to 135° included point angle.

Use narrow land reamers ground to a 30° angle chamfer and with a 5 to 10° face rake.

Use standard milling cutters with 5° (P) and 10° (S) relief back of cutting edges to prevent drag.

Use standard taps ground to a hook angle of about 7° to 10°.

Use tangent, milled, or hobbed type insert thread chasers ground to 15° rake, 5° relief angle and 20° throat angle.

For drilling, form cutting, and reaming, use chlorinated sulfurized oils.

For general turning, a water-base chemical coolant is recommended.

All oils and coolants should be completely removed from the metal prior to any heating operations.

Table 3. Forming Tests on Annealed [illegible]-inch Alloy 718 Sheet

	Flange Length	Remarks
[illegible]-ton Hydropress	1.[illegible] stretch flange [illegible] shrink flange	Three wrinkles in shrink flange, diagonal buckle in stretch flange side
[illegible]-ton Hydropress 1/2-inch hard-lead overlay with 2 soft lead straps[a]	1.[illegible] stretch flange [illegible] shrink flange	No wrinkles in either flange, slight web warpage
Impact rubber formed 1/2-inch hard lead overlay	[illegible] stretch flange [illegible] shrink flange	Slight web warpage, slight wrinkling of shrink flange and at ends of stretch flange
Impact rubber formed Soft lead-strip overlay at shrink flange Restrike without overlay	[illegible] stretch flange [illegible] shrink flange	Slight web warpage, small wrinkles present in shrink flange, slight warpage at one end of stretch flange
Impact rubber formed 1/2-inch hard-lead overlay Reduced heavy shrink flange wrinkles by hand forming with soft lead straps Restrike 2 times Repeat above	[illegible] stretch flange [illegible] shrink flange	Slight wrinkles not completely removed by hand working and restriking operations

(a) The hard lead overlay consisted of lead alloyed with [illegible] antimony.

Ref. [illegible]

Table 4. Types of Failure in Sheet-Forming Processes

Process	Cause of Failure: Splitting	Cause of Failure: Buckling
Brake forming	•	
Dimpling	•	
Beading		
Drop hammer	•	
Rubber press	•	
Sheet stretching	•	
Joggling	•	•
Liner stretching	•	•
Trapped rubber, stretching	•	•
Trapped rubber, shrinking		•
Roll forming		•
Spinning		•
Deep drawing		•

Ref. [illegible]

alloy in a like condition. Since there is some dimple-formability information available on René 41, this was used to estimate the ratio of the dimple slant height, H, to the radius of the dimple hole, R. For a 100-degree fastener, the ratio is H/R = 1.17 for René 41 at room temperature. With a dimple depth of 0.045-inch, as was specified, a slant height of 0.070 inch would be obtained. The maximum hole diameter for the dimple would therefore be increased from 100 degrees to say 120 degrees, which would give an H/R ratio of 2.00. It is doubtful whether increasing the temperature of dimpling from room temperature will increase the capabilities for dimpling, since the limits depend on the elongation values for the material. Examination of the elongation values for Alloy 718 at various temperatures indicates that they are about the same from room temperature to approximately 1000 F. At higher temperatures, the elongation is reduced and the properties of the material can be affected by overaging.

Ref: 8

HEAT TREATING

The effects of various annealing cycles on the microstructure of Alloy 718 are reported by McDonnell Aircraft Corporation. Test specimens of 0.040-inch material were overaged at 1400 F for 30 hours and then annealed 15 minutes at temperatures from 1500 F to 2150 F.

Annealing temperatures below 1700 F failed to dissolve the particles precipitated during aging. Temperatures between 1700 and 1800 F adequately dissolved precipitated phases so that subsequent aging produced maximum hardness. Annealing overaged material at 1900 F for 15 minutes appeared to completely dissolve precipitated phases, without altering precipitation behavior during subsequent aging or encouraging excessive grain growth. Annealing temperatures greater than 1900 F produced excessive grain growth and led to the formation of undesirable grain-boundary films during subsequent aging.

No variation in hardness or microstructure was found to result from air cooling or water quenching from annealing temperatures.

DPH hardness of water- and air-quenched specimens and photomicrographs of the grain s[illegible] ture of heat-treated specimens are given [illegible] references.

Ref: 55049 McDonnell Aircraft Corp[illegible]
Report A470, (December 12, 19[illegible]

At the present time, there is no [illegible]dard" heat treatment for Alloy 718. Rather, the heat treatment is tailored to fit a specified application and chemical composition. Most of the heat treatments currently being used with this alloy have in common the steps of solution treating and double aging, resulting in the precipitation of the gamma-prime phase (see Metallography). Several such treatments are tabulated on the next page.

Solution Treatment

The solution treatment employed with this alloy has undergone a major change since the alloy was first developed. This has involved a complete reversal of the long-standing idea that high solutioning temperatures were optimum for creep-limited applications and low solutioning temperatures for tensile-limited applications. The aircraft engine manufacturers, desiring good creep-rupture life, have found that 1700 to 1750 F for 1 hour is the preferred solutioning temperature.[a] On the other hand, when good tensile properties are desired, the solutioning temperature is now specified as 1950 F. The latter treatment seems to be preferred also when toughness at cryogenic temperatures is required in service.

Solution treating is followed by quenching or air cooling, depending on size. Air cooling should be at a rate of around 400 degrees F per minute. Slow cooling (such as air cooling of heavy sections) can result in low yield strengths after aging.

The main reason for not using the 1950 F solution treatment in creep-limited applications is that it reduces rupture ductility. The trend toward using the high solutioning temperature for tensile-limited applications has been accompanied by a lowering of the aluminum content of the alloy.

Aging Treatment

For optimum properties, particularly ductility, a double aging treatment is now employed. Initial aging is performed within the range 1325 to 1400 F, usually for 8 to 10 hours. The use of higher temperatures and longer times promotes the transformation of the preferred gamma-prime phase to the more stable, orthorhombic Ni_3Cb phase. For this reason, aging is usually completed within the range 1150 to 1200 F, usually for an additional 8 hours. Furnace cooling is employed in going from the first aging temperature to the second.

The selection of aging temperatures within the ranges given above is related to the intended application and, possibly, to the chemical composition. Data on the interrelationships between chemical composition, heat-treatment details, and

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(a) Strictly speaking, this is an annealing treatment, since complete solution does not take place below 1750 F.

Typical Heat Treatments for Alloy 718

Specification	Company	Solution Temp., F	First Aging Temp., F	Second Aging Temp., F	Aging Method (a)
AMS 5596A	Society of Automotive	1750	1325	1150	I or II
AMS 5597A	Engineers	1950	1400	1200	
B50T69-S6	General Electric Company	1700	1325	1150	I
C50T79(S1)	General Electric Company	1800	1325	1150	I
PWA 1009-C	Pratt and Whitney Aircraft	1750	1325	1150	I or II
EMS-581c	AiResearch	1950	1350 (b)	1200	I
RB0170-101	Rocketdyne	1950	1400	1200	III
AGC-44152	Aerojet-General	1950	1350	1200	IV

(a) I: Hold 8 hours at first aging temperature, furnace cool at 100 F/hr to second aging temperature. Hold 8 hours, air cool.
II: Hold 8 hours at first aging temperature, furnace cool to second aging temperature. Hold at second aging temperature until total time elapsed since the beginning of the first aging is 18 hours.
III: Hold 10 hours at first aging temperature, furnace cool to second aging temperature. Hold at second aging temperature until total time elapsed since the beginning of the first aging is 20 hours.
IV: Same as II, but first aging time may be 8 to 10 hours.

(b) F on certain heavy forgings.

resulting mechanical properties are still being accumulated and more data are needed before optimum aging temperatures can be recommended.

Heat Treating Precautions

During aging, Alloy 718 exhibits a linear contraction of about 0.001 inch per inch.

This alloy is susceptible, as are similar nickel-base alloys, to sulfur embrittlement and attack by elements such as lead, bismuth, etc. For this reason, all foreign material such as grease, oils, paints, etc., must be removed by suitable solvents prior to heat treatment. The alloy should be supported on clean brick or a plate of heat-resistant alloy to reduce contamination. Natural gases or low-sulfur oils should be used for fuel, and slightly oxidizing atmospheres are recommended to reduce sulfur pickup.

Ref: 53601, 61368, 66882

CLEANING

Cleaning is very important to the successful welding, coating, hot forming, and stress relieving of nickel-base alloys. Two main types of surface contamination must be removed by cleaning:

(1) Surface dirt such as paint, grease, and oil
(2) Oxide films and scales.

Proper surface preparation is necessary to:

(1) Prevent the harmful effects of sulfur, lead, and other elements that are often present in paint, oil, and other surface dirt

(2) Prevent the entrapment of oxide film or scale.

Among the methods that are used to clean metal surfaces in general prior to welding are alkaline or solvent cleaning, vapor degreasing, and pickling.

The degree of cleanliness before, during, and often after welding can affect weld quality. Welding should be performed as soon as possible after cleaning, since oxides begin to form immediately after exposure of cleaned surfaces to open-air atmospheres. Although the oxides may be extremely thin and invisible, they can reduce the quality of weldments made by resistance welding and solid-state diffusion welding.

The importance of obtaining a clean surface prior to coating cannot be overemphasized. The

presence of dust, dirt, oxides, oil, grease, fingerprints or similar contaminants on the surface of a part being coated can result in the formation of a coating that is discontinuous, has poor adhesion, and exhibits inferior properties. Specific cleaning procedures for preparing the surfaces of nickel-base alloys prior to coating are generally regarded as proprietary; this is particularly true in the case of cleaning prior to the application of diffusion coatings. Among the methods that are used are polishing on a cotton wheel, vapor blasting, grit blasting, and pickling.

Degreasing can be accomplished by washing in a warm detergent, rinsing, and drying in an oven, or by the use of organic solvents.

There is relatively little information that is available specifically on the cleaning of Alloy 718. However, it appears that many of the cleaning methods used for other nickel-base alloys can be applied to this particular alloy.

Before pickling of this alloy is attempted, it is recommended that producers of Alloy 718 and producers of proprietary pickling materials should be contacted for additional information. Two particularly knowledgeable sources of information on pickling are the Huntington Alloy Products Division of International Nickel Company, Inc., and the Stellite Division of Union Carbide Corporation.

Ref: 64660, 62547

COATINGS

Most diffusion coatings used in the United States for nickel-base alloys are rich in aluminum. They are used primarily to protect parts of aircraft, marine, and automotive gas-turbine engines from the degrading effects of the service environment. There is still much room for improvement in these coatings, particularly in those for engines that will be used near the sea. Under such circumstances, the salt content of the air, combined with sulfur from the jet fuel, causes a new, severe type of sulfidation attack.

Diffusion coatings based on boron have been developed in the Soviet Union as a means of obtaining very hard cases on nickel-base alloys.

Nickel alloys generally are not electroplated or electroless plated, both because they are not used in applications in which plating is required and because they often inherently possess the corrosion resistance or other attribute for which plates are applied. In the relatively few applications where they are electroplated, care must be taken to first remove the passive surface film that occurs naturally on these materials.

Hard facings are not often applied to nickel-base alloys. However, examples are known in which hard facings have imparted to these materials the required resistance to steam erosion, erosion-corrosion, or wear.

Surface treatments have been developed that provide nickel-base alloys with lubricity under conditions in which oils and greases would deteriorate, such as at high temperature and high vacuum.

Although there seems to be little information available on the specific application of coatings to Alloy 718, it appears that many of the treatments used with other nickel-base alloys could be applied to this alloy.

Coating treatments for nickel-base alloys are discussed in detail in Reference 64660.

Ref: 64660

JOINING

The excellent weldability of Alloy 718 is attributed to the relatively slow rate of precipitation of the strengthening phase, gamma prime. Because of this, little hardening occurs during welding.

The greater portion of the fusion welding of Alloy 718 has been done by the gas tungsten-arc (TIG) process. The gas metal-arc (MIG) and electron-beam processes have been used, but to a lesser extent. No data have been found for the shielded metal-arc or submerged-arc processes.

Weld-cracking problems have been associated, by some users, with a high solution-annealing temperature. It has been reported that there is a close relationship between the solution-annealing temperature and the tendency to form microfissures. As the solution annealing temperature is increased, the tendency to form microfissures is increased.

Ref: 57516, 64912, 66682

TIG Welding

Limited data indicate that a weld efficiency of 90 percent may be obtained in the gas tungsten-arc welding of Alloy 718 plate. This value is applicable over the temperature range -423 to 1500 F for material that is fully heat treated after welding.

Weld efficiency represents the ratio of tensile yield strength or tensile ultimate strength of the weldment to that of the parent metal. In a limited testing program, North American Aviation, Inc., welded a number of specimens from one heat of 1/4-inch Alloy 718 plate, using Alloy 718 filler metal. Both parent-metal and as-welded specimens

were then annealed (1900 F/1 hour/air cool) and aged (1400 F/10 hours + 1200 F/10 hours) before testing. Multiple tests were run at each of five temperatures: -423, room, 1000, 1200, and 1500 F. Weld efficiencies were computed at each temperature for specimens from which the reinforcement had been removed. At each temperature, the average yield or ultimate strength at the weldment was from 99 to 108 percent of the corresponding value for the parent metal.

Investigation of the chemical composition of the test materials indicated that the parent metal had a much lower aluminum content (0.27%) than did the filler metal (0.50%). Prior experience at Rocketdyne has indicated that heats containing less than 0.35% aluminum do not respond well to the indicated heat treatment. Thus, the observed weld efficiencies are probably higher than should be expected, and the investigators recommended the use of 90 percent weld efficiency for design purposes.

Ref: 63646, Betts, R. D., "Weld Efficiencies of Inconel 718 Gas Tungsten Arc Welds in the -423 to 1500 F range", North American Aviation Report MPR 5-175-363 (July 27, 1965).

Alloy 718 has been welded by the TIG process in thicknesses ranging from 0.020 to 1.5 inches. The use of filler metals is optional. Argon is the protective gas commonly used, but helium is preferred for deep-penetration welds. Cleaning of the joint areas in preparation for welding must be complete if fully efficient joints are required. Also, light interlayer grinding should be used between passes.

The alloy is similar to other nickel-base alloys in its inability to flow readily when molten. Consequently, in most joints over about 0.125-inch thick, joint designs which contribute to full joint penetration are necessary. During a study at the General Electric Company, investigators encountered considerable difficulty in obtaining a joint design in which full-penetration welds could be assured. Several different filler metals and joint configurations were evaluated. It was concluded that U-grooves were best.

In the same study, the investigators also considered the effect of both argon and helium as shielding gases. It was determined that the choice of shielding gas affected the results obtained, especially in the thicker plates. Consistent penetration and high welding speeds were more readily obtained when using helium on 0.25-and 0.50-inch plate. Porosity was also decreased by using helium. However, if the weld is properly made, its properties will not be affected by the shielding gas. Optimum TIG weld settings for plate, when helium shielding gas is used, are presented in Table 5. Slight modifications to suit local situations are possible.

The effect of different shielding atmospheres was also studied at McDonnell Aircraft Corporation for TIG butt-welds in 0.045-inch sheet. No difficulties were encountered with either helium or argon atmospheres. However, helium-shielded welds required considerably less heat input and resulted in a cleaner weld appearance. No other effects were detected. Process settings used in this study are shown in Table 6.

Several filler metals have been evaluated during weldability studies of Alloy 718. René 41 and Alloy 718 filler metals received the most attention because the weld metal will respond to aging treatments. The data indicate that there is little choice between using Alloy 718 and René 41 as the filler metal for welds in sheet stock. Shop experience has shown that more process problems have occurred when René 41 was used. Automatic or semiautomatic welding using Alloy 718 as filler is a preferred proces. Where manual welding is necessary on sheet-metal joints, the procedures must be very carefully controlled.

Studies in highly restrained welds in plate thicknesses ranging from 0.75 to 1.50 inches were conducted by the Huntington Alloy Products Division of The International Nickel Company. When welding with René 41 filler metal within the thickness range tested it was concluded that:

(1) There is no need for weld stress relief prior to aging

(2) Heavy sections can be welded in the fully aged condition even under restrained conditions

(3) Welds in heavy sections can be repaired without annealing and the repair welds aged without difficulty

(4) The stress-rupture properties of welds at 1200 and 1350 F exceed those of the base metal.

Freedom from cracking of the weld was used as the criterion for the first three conclusions.

In their studies of 0.25- and 0.50-inch-thick Alloy 718, General Electric reported on the use of Inconel 69, Hastelloy W, and Hastelloy R-235 filler wires. As expected, the maximum properties in heavy thicknesses were obtained when hardenable filler wires were used. This is because the bulk of the weld deposit is composed of filler material. The results indicated that Hastelloy R-235 filler wire produces good weld tensile and rupture properties in thick Alloy 718. Inconel 69 filler wire did not give satisfactory results. Hastelloy W filler wire gave welds with lower properties, but its welding characteristics justify its use where maximum strength is not a requirement.

Table 5. Optimum TIG Weld Settings for Alloy 718 Plate When Helium Shielding Gas is Used[a]

Thickness, in.:	0.250			0.500[c]		
Pass number	1	2	3	1	2	3
Current, amp	70-75	70-75	80-85	90-95	90-95	100-110
Arc voltage[b], v	13-15	13-15	14-16	14-16	14-16	15-17
Weld speed, in./min	1.5-2.0	1.5-2.0	1.5-2.0	2.0	2.0	2.0
Filler wire, dia., in.	0.063	0.094	0.094	0.063	0.094	0.094
Wire feed rate, in./in.	2	4	4	2	4	4
Torch gas, cu ft/hr	30	30	30	35	35	35

(a) Joint design: 0.156 root radius, 0.04-0.05 land single U-groove.
(b) Voltages are averages owing to erratic nature when using helium.
(c) Five or six passes are needed for 0.5-inch plate.

Table 6. Process Settings for Automatic TIG Welds in Alloy 718 Sheet

Thickness, in.:	0.045 Sheet	
Shielding Gas:	Argon	Helium
Current, amp	80	40
Arc voltage, v	8-16	16-18
Weld speed, in./min	8	6-8
Filler wire dia., in.	0.030-0.035	0.030-0.035
Wire feed rate, in./min	12-15	8-9
Torch gas, cu ft/hr	20-24	20
Backup gas, cu ft/hr	4	4

The results of a study conducted as part of the Supersonic Transport Research Program on TIG welds in 0.025-, 0.050-, and 0.125-inch sheet, using no filler, indicated that Alloy 718 exhibits exceptional welding characteristics for its alloy class. By observing the normal procedures employed for cleaning and welding nickel-base alloys it was possible to obtain defect-free welds consistently. Circular patch tests indicated no "hot short" problem, and simulated repair welds were made without cracking. It was determined that the alloy can be welded in the annealed or in the cold rolled (20%) and aged condition. Bend tests were conducted on the welded samples and a minimum bend radius of 1t was obtained for the 0.025-inch gage and 4t for the 0.125-inch gage.

Hot cracking can be a serious limitation to the use of Alloy 718 filler wire for welding highly restrained joints because of its low freezing temperature. In this case, René 41 filler wire is preferred.

Ref: 49184, 49649, 53601, 66882

Electron-Beam Welding

Although it is known that Alloy 718 has been the subject of electron-beam welding studies, there are very few data available. Rocketdyne reports that butt welds in parts up to 0.875 inch thick can be made with commercial equipment and by welding from each side. Weld strengths equal to that of the duplex-aged base metal are obtained. The welds are more gas-free than the base metal, and shrinkage is greatly reduced in comparision with gas tungsten-arc welds. Shrinkage in 0.75-inch Alloy 718 was 0.005 inch when electron-beam welded and 0.080 inch when tungsten-arc welded.

Two-pass welding procedures were required for welding 0.060-inch-thick Alloy 718 pressure vessels at Airite Products Division of Electrada Corporation. Single-pass welds did not give reproducible results. The procedure developed to make the two-pass welds was as follows:

Tack Weld --- 80 kv, 1.5 ma, 0.012 defocused beam at 20 in./min

Penetration Weld --- 110 kv, 6.0 ma, 18 in./min

Cover Weld -- 80 kv, 2.0 ma, 0.100 defocused beam.

Butt welds were made in 0.025- and 0.125-inch Alloy 718 in the fully aged condition. A 0.020-inch strip was used on the back side of the joint to improve the bead contour. Good reproducibility and weldability were reported when using 3-kw high-voltage equipment. Properties of the joints are not available.

Electron-beam welding should be desirable for Alloy 718 pressure vessels up to about 0.125-inch thick. This of course depends on

the economics involved and the fact that the width of the heat-affected zone increases with the lower welding speeds needed for thicker materials.

Ref: 53601, 54895, 57516

Resistance Welding

Resistance welding, particularly spot and seam welding, have become increasingly important to the fabrication of high-performance vehicles. The use of welded components in place of rivets or other mechanical fasteners in these vehicles eliminates significant weight at no sacrifice of strength. Consequently, determination of the resistance weldability of Alloy 718 has been the subject of much study.

By taking the proper precautions, Alloy 718 can be resistance seam and spot welded. The development of optimum welding procedures was found to be more difficult for 0.020-inch material than for 0.060-inch sheet. Optimum welding procedures for thin-gage material now call for welding schedules with increased weld times at lower current amplitudes. The use of very flat electrode-tip radii when welding thin sheet helps to maintain sheet-to-sheet contact.

In one study, spot-weld diameters of 0.100 inch for 0.020-inch sheet and 0.240 inch for 0.060-inch sheet permitted spots as close as 0.188 and 0.500 inch, respectively, before shunting occurred. The minimum edge distance were 0.125 and 0.250 inch, respectively, for these welds. The results of a comparison between aged-plus-welded specimens and welded-plus-aged specimens indicated that the lap shear strength of single spot-weld joints was improved by aging after welding. However, when the aged-plus-welded procedure was used, cross tension results were about 10 percent higher. The ductility ratio (cross tension/lap shear) indicated that aging after welding decreased ductility. However, the ductility ratio did not fall below 30 percent. This is considered to be adequate resistance weld-joint ductility.

Typical spot-weld machine settings are given in Table 7.

A study by Padian and Robelotto has shown that a satisfactory seam weld should be at least twice as wide as the thickness of the sheet, have at least 30 percent penetration into each sheet, and have 20 to 40 percent overlap. Seam welding parameters established by the study are given in Table 8. Those seam welded samples which were aged after welding exhibited the best strength properties.

Ref: 44973, 55127, 57516, 58334, 66882

Brazing

The brazing of the age-hardenable nickel-base alloys usually presents problems of technique such as the maintenance of very dry furnace atmospheres or precoating. The aluminum and titanium in these alloys causes difficulty in obtaining proper brazing-alloy wetting. Columbium does not oxidize to form a seriously unwettable surface. Alloy 718 contains a total of about 1.4 percent of aluminum and titanium as compared with about 4.6 percent for René 41 and 3.2 percent for Inconel X-750. Consequently, it would be expected that Alloy 718 would be much easier to braze than many age-hardenable nickel-base alloys. Tests have shown that this is true. Brazeability is comparable with that of precipitation-hardening stainless steels such as 17-7PH or PH 15-7 Mo.

McDonnell Aircraft has compared the wettability of Alloy 718 by three nickel-base and three silver-base filler metals. The specimen surfaces were prepared by alkaline cleaning followed by liquid honing before brazing. Standard volumes of brazing filler metal were placed on flat specimens and brazed in a vacuum furnace. The results are tabulated in Table 9. As expected, the nickel-base filler metals appear most suitable for Alloy 718. In addition the limited strength of silver-base brazing filler metals would preclude their use in many Alloy 718 applications.

As a result of the above study, tests were made to determine the room-temperature shear strength of joints made in Alloy 718 using filler metals CM 52 and CM 56 LC. The specimens were cleaned as in the previous work and brazed in a vacuum of 1 micron or less. Three temperatures (1950, 2000, and 2050 F) and two brazing times (3 and 15 minutes) were used for each alloy.

Although the strongest joints were obtained with the 15 minute brazing cycle, it was concluded that long cycles were detrimental from two aspects: serious intergranular penetration by the filler metal, especially CM 56 LC, and possible adverse thermal effect on the Alloy 718. It has been reported that brazing above 1800 F may reduce the elongation of aged Alloy 718 base metal in the temperature range 1200-1500 F. The McDonnell work was on unaged alloy.

A study was conducted at North American Aviation to determine whether any reduction in heat-treated mechanical properties of Alloy 718 would occur owing to brazing at temperatures in excess of optimum solution-treating temperature. The results indicate a degradation of between 15 and 20 percent.

Gold-nickel and copper-gold brazing filler metals have been evaluated for fabricating Alloy 718

Table 7. Typical Spot-Weld Machine Settings for Alloy 718 Sheet

Thickness, in.: Condition:	0.020 As Recd.	0.020 Aged	0.060 As Recd.	0.060 Aged
Preheat heat, percent	---	8	---	---
Preheat impulses	---	2	---	---
Preheat time, cycles	---	10	---	---
Weld heat, percent	16	16	40	38
Weld impulses	2	2	2	2
Weld time, cycles	4	10	8	8
Current decay heat, percent	10	---	35	35
Current decay time, cycles	3	---	6	6
Cool time, cycles	0.5	0.5	1.5	1.5
Squeeze time, cycles	21	21	21	21
Hold time, cycles	50	50	61	61
Weld force, lb	660	750	2850	2900
Forge delay(a), cycles	11-B	11-B	0-E	0-E
Forge force, lb	1500	1950	5380	5400
Electrode class, RWMA	III	III	III	III
Electrode diameter, in.	5/8	5/8	5/8	5/8
Electrode radius, in.	3	10	5	5

(a) B-beginning of weld; E-end of weld.

Table 8. Typical Seam-Weld Machine Settings for Alloy 718 Sheet

Thickness, in.: Condition	0.020 As Recd.	0.020 Aged	0.060 As Recd.	0.060 Aged
Weld heat, percent	45	45	65	65
Weld impulses	4	4	8	[illegible]
Weld time, cycles	5	5	4	4
Cool time, cycles	0.5	0.5	0.5	0.5
Drive	(a)	(a)	(a)	(a)
Tip force, lb	800	800	2900	2900
Forge time, cycles	5	5	5	5
Wheel class, RWMA	III	III	III	III
Wheel thickness, in.	1/2	1/2	1/2	1/2
Wheel radius, in.	3	3	3	[illegible]
External cooling	Yes	Yes	No	Yes

(a) Intermittent

DMIC handbook

Table 9. Wettability of Alloy 718 by Various Brazing Filler Metals

Brazing Alloy[a]	Chamber Pressure, mm Hg x 10^{-4}	Brazing Temp., F	Brazing Time, min	Wetted Area, in.^{2}	Contact Angle, deg	Wettability Index[b]
CM 50[c]	5	1950	15	0.185	21.6	0.172
CM 52	4	1990	15	0.762	12.8	0.743
CM 56LC	4	2075	15	0.624	11.6	0.611
LB 925[d]	5	1660	10	0.189	--	--
LB BT[e]	3	1625	10	0.097	--	--
LB 846	4	1750	10	0.276	38.5	0.215
CM 50[f]	5	1950	15	0.236	25.4	0.213
CM 52	5	1990	15	0.414	27.6	0.367
CM 56LC	4	2075	15	0.542	17.3	0.518
LB 925	5	1660	10	0.206	53.5	0.122
LB BT[g]	3	1625	10	0.096	115.2	-0.087
LB 846	4	1750	10	0.246	53.5	0.146

(a) CM = Coast Metals; LB = H & H Lithobraze.
(b) Area times cosine wetting angle; index >0.6 indicates excellent wetting, <0.1 poor wetting.
(c) Sintered, not fused.
(d) Incomplete fusion.
(e) Fused, no wetting.
(f) Sintered, not fused.
(g) Very little wetting.

honeycomb structures. The gold-base alloys wet the base metal well in a vacuum of less than 1 micron; the copper-base alloys did not. In this study crevice corrosion tests were made in a salt spray and aerated water. No evidence of corrosion was found after 100 hours.

The gold-base filler metal containing chromium appeared to be stronger in both lap-shear tests and edgewise compression tests of honeycomb structures. The strength advantage, however, may be lost because of greater degradation of the base metal caused by the higher brazing temperature required.

Alloy 718 can be brazed with relative ease if the proper procedures, approximating those for other aluminum/titanium-containing superalloys, are used. Specimens of the base metal should accompany brazed specimens throughout the brazing and subsequent heat-treatment cycles to determine the effect of these operations on the mechanical properties of the base-metal.

Ref: 50206, 54026, 55050, 57516

Adhesive Bonding

Nickel-base alloys can be adhesive bonded successfully using presently available techniques and adhesives. Relatively little work has been done on adhesive bonding of these alloys, however, because nickel-base alloys generally are used at temperatures above the present maximum service temperatures of organic adhesives or under corrosive conditions. Inorganic adhesives of sufficient ductility and low enough maturing temperatures have not as yet been developed to compete with brazing and welding techniques for joining parts for high-temperature structures. As the maximum service temperatures of new organic adhesives continue to increase, production applications of adhesive bonding to nickel-base alloys may become more attractive.

Ref. 62549 is recommended as an excellent summary of the state-of-the-art of adhesive bonding of nickel-base alloys.

Ref: 62549

SURFACE FINISHING

Mechanical surface treatments such as burnishing, explosive hardening, peening and planishing are not used to any great extent for nickel-base alloys. When used, they serve a variety of functions including improving surface finish, increasing fatigue strength and surface hardness, and reducing the occurrence of weld cracking. Improvements in mechanical properties arise largely as a result of the residual compressive stress established in the surface of the metal by the treatments.

Although there seems to be little information available on the specific application of mechanical surface treatments to Alloy 718, it appears that many of these treatments could be applied to this alloy.

Mechanical surface treatments of nickel-base alloys are discussed in detail in reference 64660.

Ref: 64660

III. APPLICATION FACTORS

Uses

APPLICATION FACTORS

USES

The following applications for Alloy 718 have been identified in the literature:

Application	Reference
Cryogenic-temperature applications:	
Diaphragms in vent and relief valves	64409
Inner shell of LOX tankage for both Gemini and LEM	64723
Elevated-temperature applications:	
M-1 turbine manifold	61919
M-1 fuel pump rotor	58539
Titan IIA chamber tube	59644
Cryogenic and elevated-temperature applications:	
Pressure vessels	58137
Point drive fasteners	65780
Saturn V hardware (bellows and gimbal structures)	64912
Alloy 718 is also undergoing tests as a candidate material for:	
SST wing and fuselage skins	57147
Ring flanges, seals, and U, L, T shapes for jet engines	66396

IV. MECHANICAL PROPERTIES

DMIC **data sheet**

Base Material: Nickel

Metal or Alloy: Alloy 718

Form:

Condition:

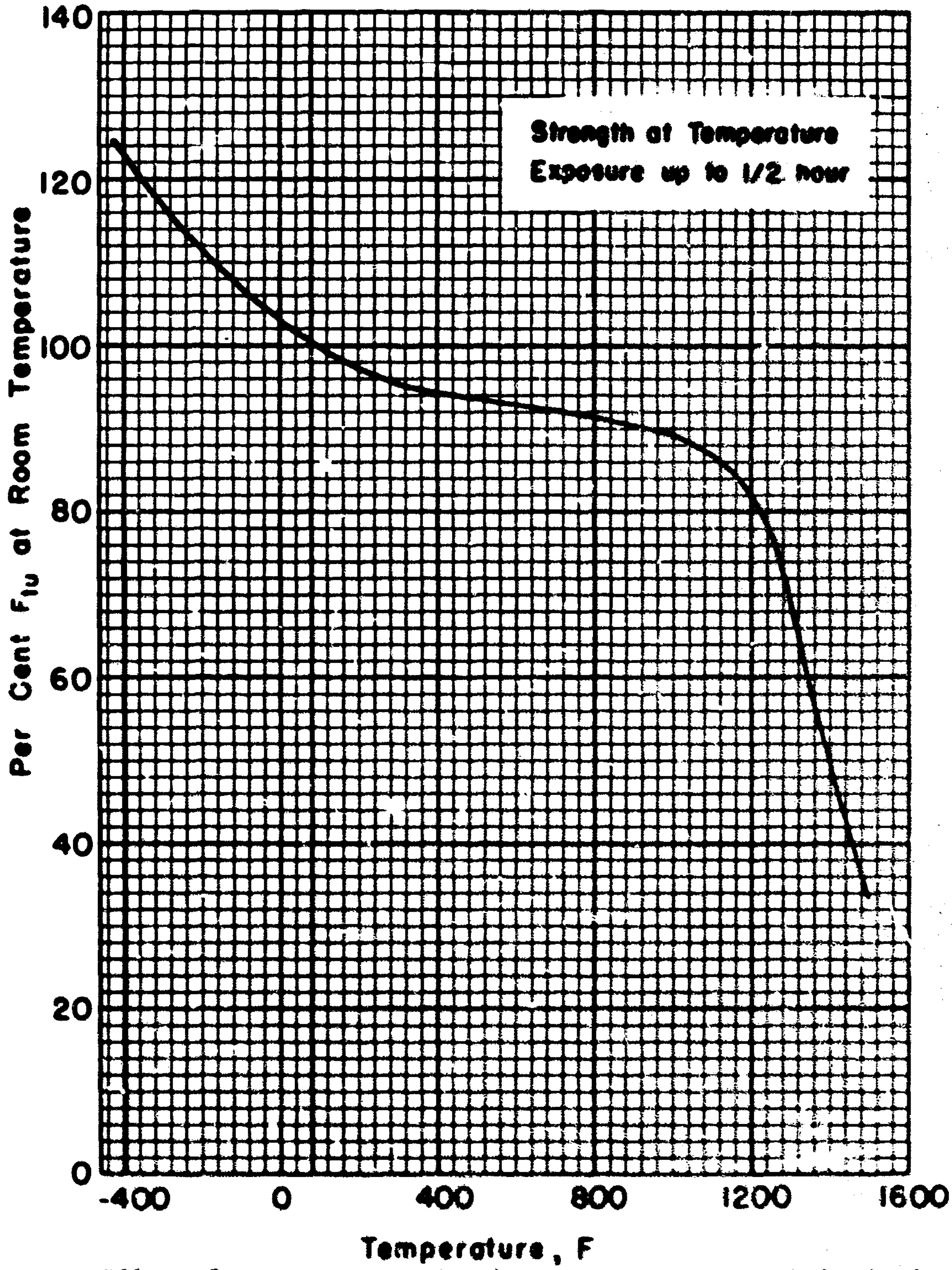
Alloy Data: Design properties

Alloy 718 has been proposed for inclusion in MIL-HDBK-5, "Metallic Materials and Elements for Aerospace Vehicle Structures". The following table and four figures were contained in an attachment to the agenda for the 34th Meeting (October 1967), which will be considered for approval at the 35th Meeting (April 1968).

Tentative Design Mechanical and Physical Properties of Alloy 718

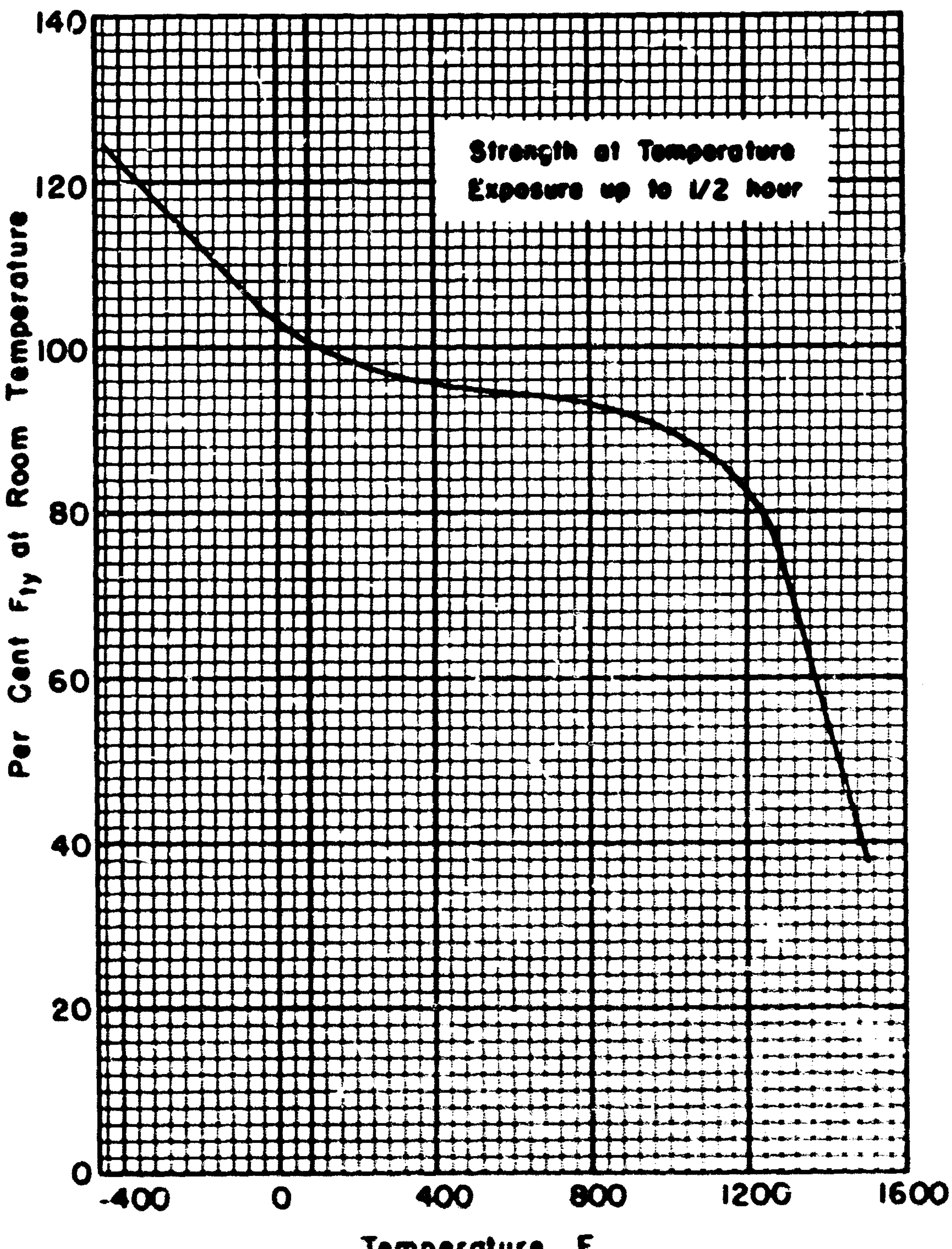
Specification	AMS 5383	AMS 5589	AMS 5590	5596, 5597	5662, 5663 5664
Form	Castings	Seamless tubing		Sheet, plate	Bars, forgings
Condition	Solution-treated & aged per indicated specification				
Thickness or diameter, in. ..	--	O. D. $\geq$ 0.125 wall $\leq$ 0.015		--	--
Basis	S**	S	S	S	S
*F_{tu}, ksi					
L	125	185	170	--	185[c]
T		--	--	180[a]	180
F_{ty}, ksi					
L	110	150	145	--	150[c]
T		--	--	150[a]	150
e, per cent:					
L	5	12	15	--	12[c]
T		--	--	15[ab]	10[d]
E, 10^6 psi	29.6[e]				
ω, lb/in.^{3}	0.297				

a Test direction longitudinal for widths < 9 in.
b Thickness > 0.025 inch.
c AMS 5662 and 5663 only. For AMS 5664 use 180/150/10 for bars, 180/150/12 for forgings.
d 12 percent for AMS 5664 forgings
e Dynamic modulus.
* Symbols are defined in the Appendix.
** See Appendix for basis of design properties.



Effect of temperature on the ultimate tensile strength (F_{tu}) of solution-treated and aged Alloy 718.
(Tentative)

DMIC data sheet



Effect of temperature on the tensile yield strength (F_{ty}) of solution-treated and aged Alloy 718.

(Tentative)

DMIC **data sheet**

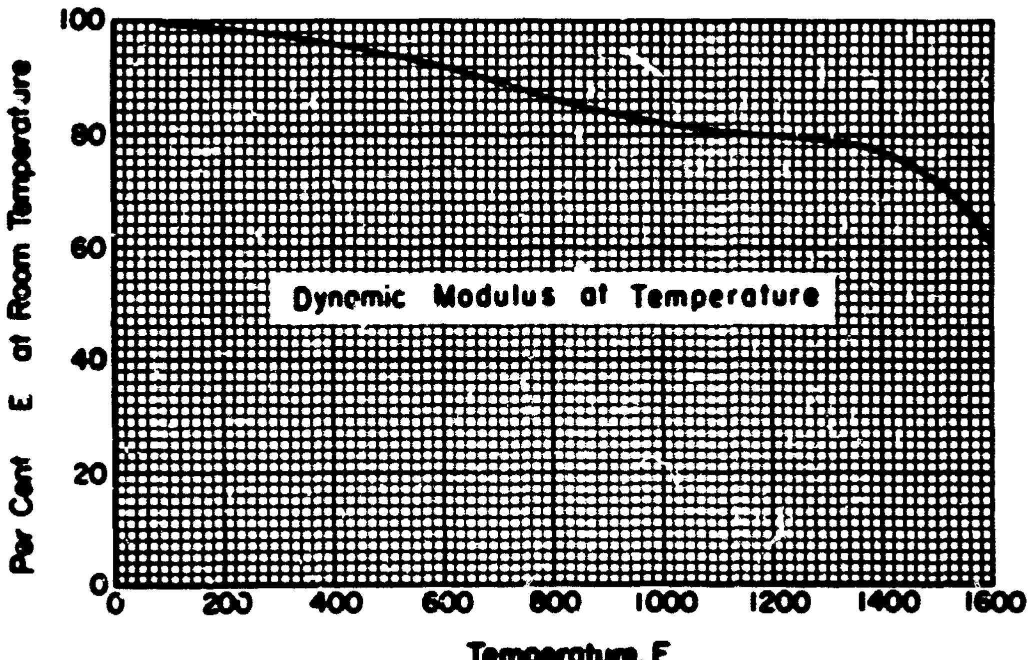
Base Metal: Nickel IV-4

Metal or Alloy: Alloy 718

Form:

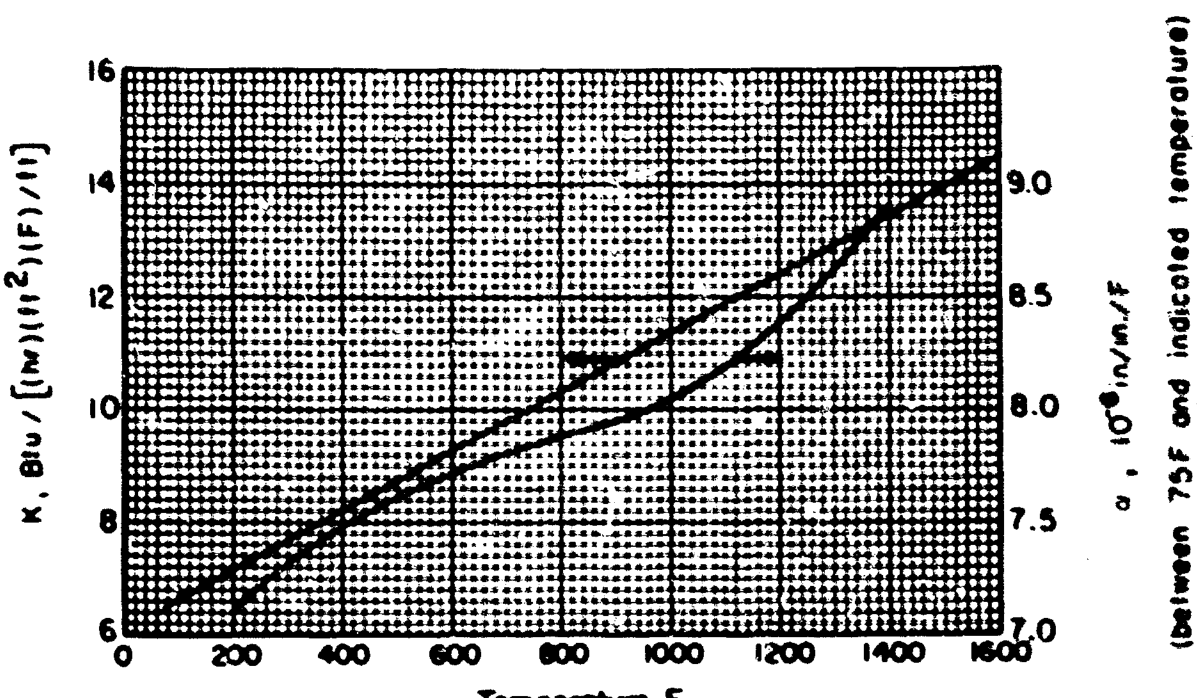
Condition:

Alloy Data: Physical properties



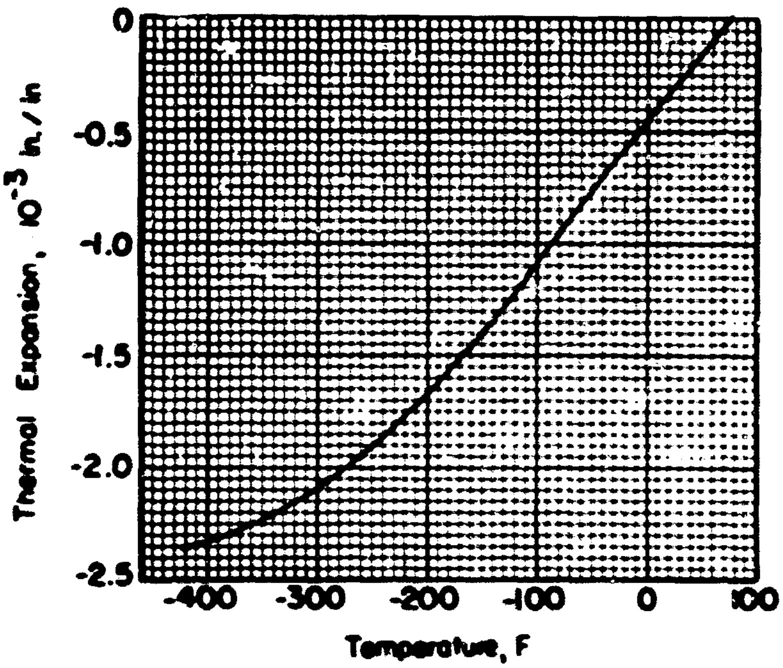
Effect of temperature on the tensile modulus (E) of solution treated and aged Alloy 718

(Tentative)



Effect of temperature on the physical properties of Alloy 718

(Tentative)



Thermal expansion of Alloy 718 between room temperature and indicated temperature (cryogenic)

Condition: Annealed at 1950 F; aged at 1350 F/8 hours + 1200 F for a total of 20 hours.

Reference: 70525

DMIC

data sheet

ACCESSION NUMBER 55794
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		267.0	312.0	17.0		L
-423		270.0	310.0	13.5		L
-423		268.0	312.0	12.5		L
-423		270.0	303.0	11.5		L
-423		268.0	310.0	10.5		L
-423		263.0	296.0	15.5		T
-423		261.0	296.0	10.5		T
-423		256.0	297.0	10.0		T
-423		267.0	296.0			T
-423		260.0	296.0	12.0		T
-320		256.0	291.0	17.5		L
-320		260.0	293.0	15.0		L
-320		258.0	293.0	15.0		L
-320		250.0	296.0	15.0		L
-320		261.0	283.0	10.0		L
-320		230.0	272.0	12.0		T
-320		236.0	266.0	11.5		T
-320		238.0	275.0	15.0		T
-320		230.0	275.0	11.0		T
-320		243.0	276.0	13.0		T
-100		237.0	260.0	11.5		L
-100		237.0	254.0	10.5		L
-100		231.0	240.0	10.5		L
-100		230.0	240.0	11.5		L
-100		229.0	247.0	10.5		L
-100		216.0	242.0	8.5		T
-100		210.0	241.0	8.5		T
-100		223.0	242.0	8.5		T
-100		214.0	241.0	8.5		T
-100		210.0	243.0	8.5		T
75		216.0	230.0	7.0		L
75		210.0	230.0	8.5		L
75		219.0	230.0	7.0		L
75		217.0	220.0	7.0		L
75		219.0	230.0	8.0		L
75		204.0	225.0	7.5		T
75		207.0	225.0	7.5		T
75		204.0	222.1	6.5		T
75		205.0	252.0	7.0		T
75		205.0	222.0	6.5		T

ACCESSION NUMBER 61090
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

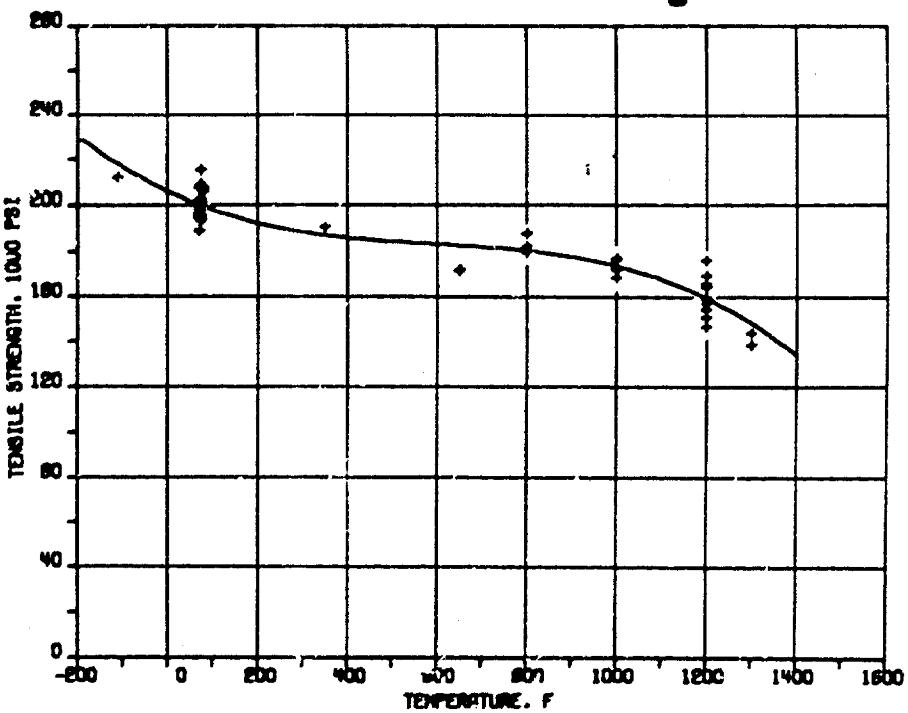
TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		111.0	107.7	60.0		
-423		103.3	100.3	62.5		
-423		99.6	108.5	64.5		
-320		101.0	106.3	67.5		
-320		98.0	107.0	58.0		
-320		102.9	106.0	56.5		
75		74.0	171.3	64.0		
75		76.0	170.0	64.5		
75		75.0	176.0	64.0		

Condition Annealed

Ref 55790 and 61090

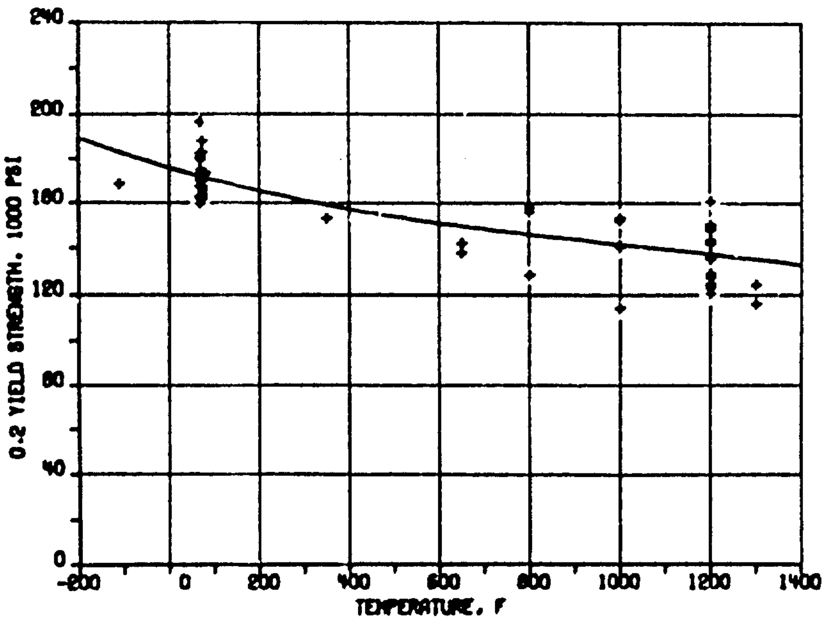
DMIC data sheet

Alloy 718 Sheet
Annealed at 1750 F and Aged

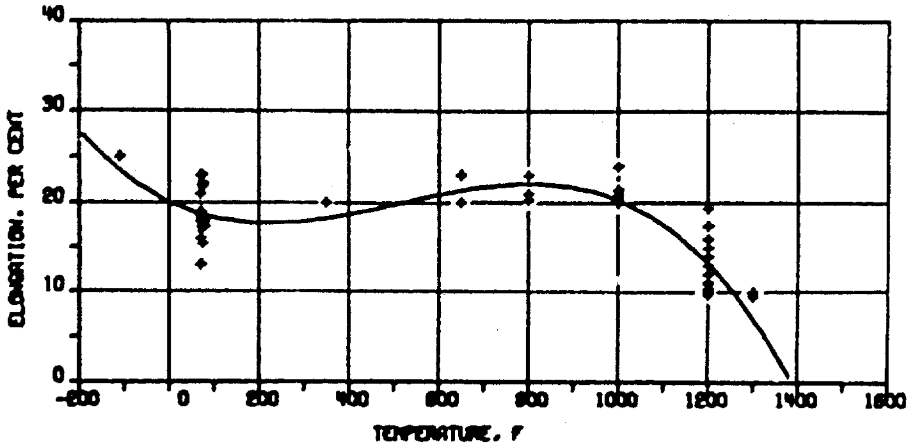


Tensile Strength

From Data On pp IV - 11 And 12



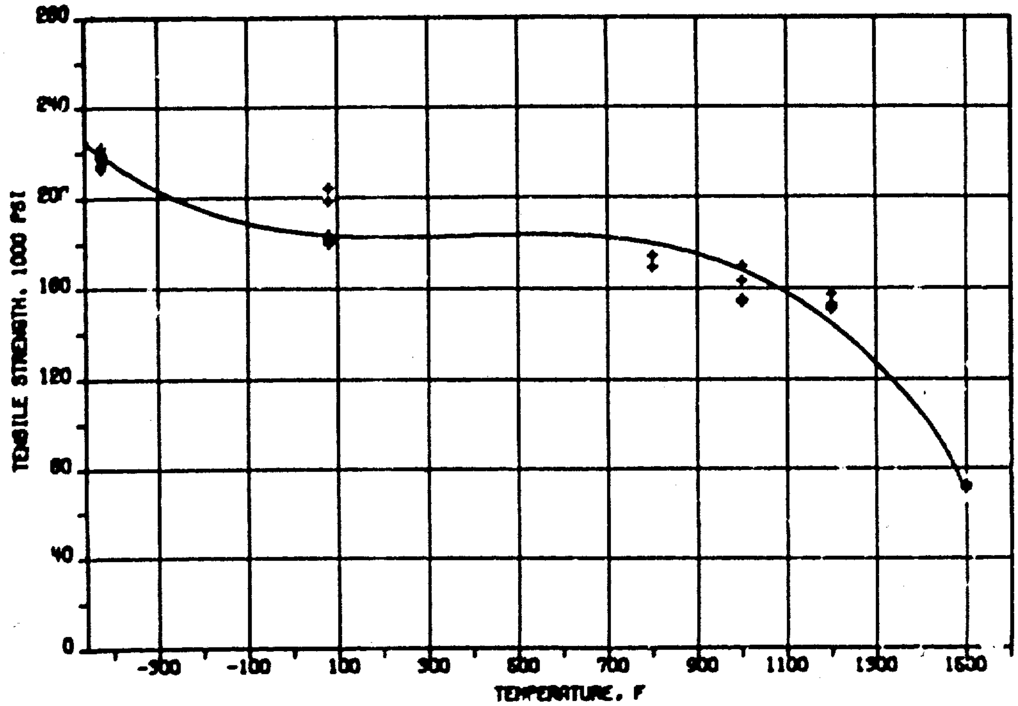
.2% Yield Strength



Elongation

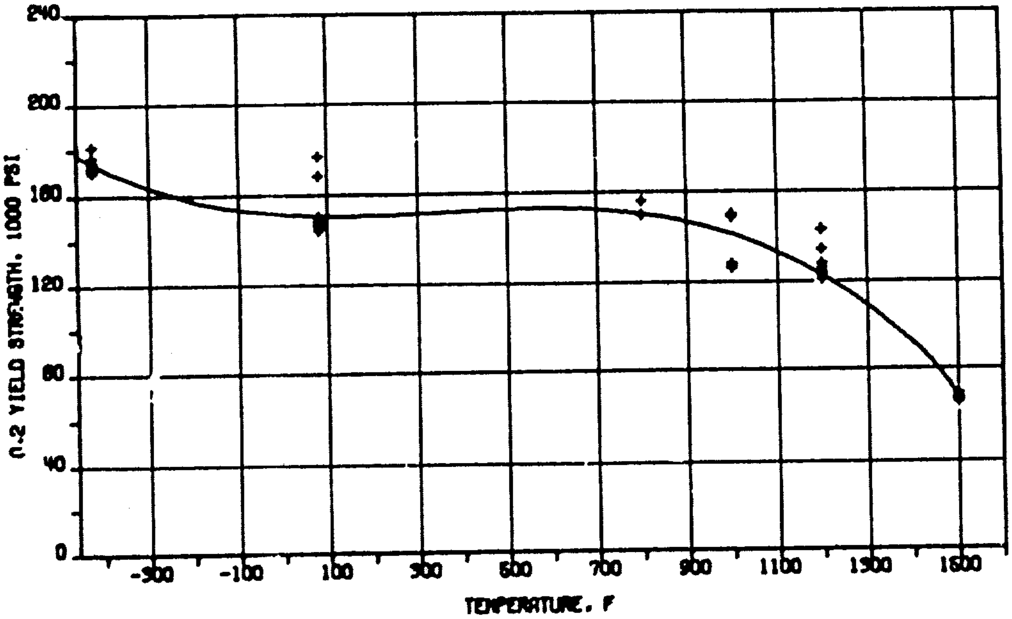
From Data On pp IV - 11 And 12

Alloy 718 Sheet and Plate
Annealed at 1950 F and Aged

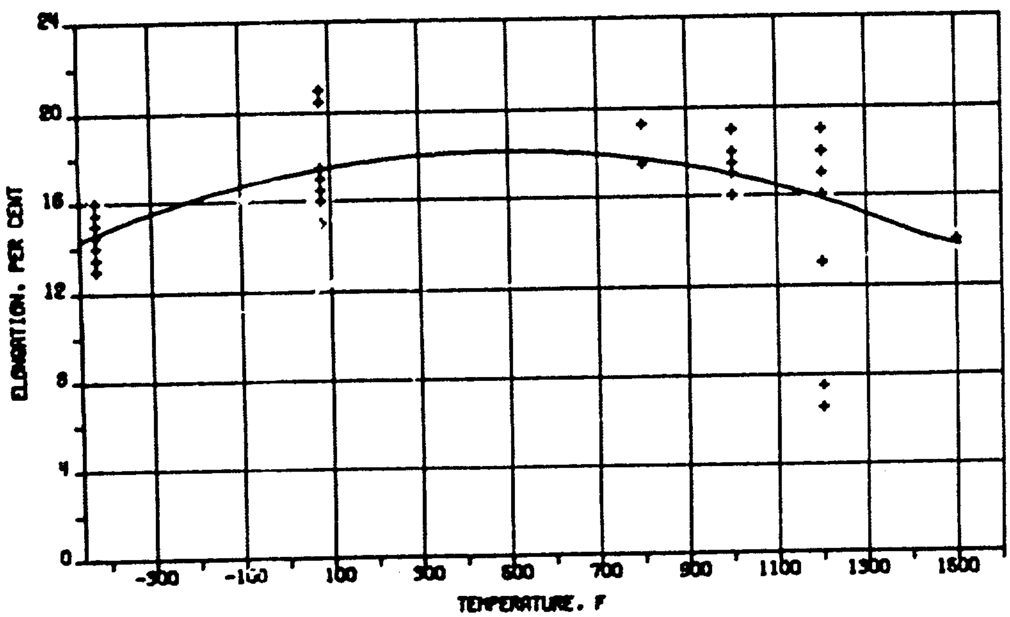


Tensile Strength

From Data on p IV-14



.2% Yield Strength



Elongation

From Data on p IV-14

DMIC

data sheet

ACCESSION NUMBER 65977

LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		163.3	196.0			T
75		164.7	198.9	20.0	27.0	T
75		166.0	195.0	16.5	29.5	L
75		162.4	195.0			L
1000		141.0	165.3	15.2	32.0	T
1000		141.0	166.9	19.5	33.0	T
1000		142.5	163.7	21.5	51.0	L
1000		144.3	164.0	23.2	48.7	L
1000		141.4	162.3	10.3	36.1	L
1200		135.2	145.1	16.2	20.6	T
1200		132.0	157.9	6.5	16.6	T
1200		135.6	155.6	9.4	14.9	T
1200		135.0	159.9	10.0	17.1	L
1200		136.1	150.7	12.0	22.1	L
1400		101.6	112.7	8.0	9.5	T
1400		99.5	113.2	9.0	8.5	T
1400		104.2	120.7	4.2	10.5	L
1400		101.3	114.0	3.6	9.0	L

ACCESSION NUMBER 67602

LOT NUMBER 22

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		157.2	190.8	18.5		
75		167.0	199.0	19.0		
1000		140.5	172.0	20.0		
1000		140.0	173.0	20.5		
1200		136.0	146.5	19.5		
1200		135.2	164.5	17.5		
1300		124.2	144.0	10.0		
1300		116.0	138.7	9.5		

ACCESSION NUMBER 67609

LOT NUMBER 39

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		159.0	189.1	23.0		
1200		127.2	141.3	14.0		

ACCESSION NUMBER 67609

LOT NUMBER 40

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		175.0	195.0	10.0		
1200		124.3	146.9	16.0		

ACCESSION NUMBER 67609

LOT NUMBER 41

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		170.0	202.0	10.0		
1200		137.2	149.0	12.0		

ACCESSION NUMBER 67609

LOT NUMBER 42

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		162.0	195.0	16.0		
1200		135.4	159.6	15.0		

ACCESSION NUMBER 67613

LOT NUMBER 24

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		169.7	194.4	18.6		
1200		150.0	169.6	10.1		

ACCESSION NUMBER 67613

LOT NUMBER 25

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		161.6	193.4	22.2		
1200		120.4	157.4	18.0		

ACCESSION NUMBER 67613

LOT NUMBER 26

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		173.8	200.6	22.1		
1200		135.1	151.3	15.0		

ACCESSION NUMBER 67613

LOT NUMBER 27

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		171.6	201.0	23.1	46.5	
1200		122.9	151.0	10.4	25.5	

ACCESSION NUMBER 67613

LOT NUMBER 28

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		163.5	195.0	10.4		

Heat Treatment and References on p IV-12

ACCESSION NUMBER 67613
LOT NUMBER 29

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		173.0	206.0	15.4		
1200		147.0	165.0	9.7		

ACCESSION NUMBER 67613
LOT NUMBER 30

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		165.0	196.0	21.0	35.6	

ACCESSION NUMBER 67613
LOT NUMBER 31

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		183.0	202.9	10.2		
1200		120.0	154.3	12.0		

ACCESSION NUMBER 67613
LOT NUMBER 32

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		167.3	215.4	17.5		
75		167.3	215.4	17.5		

ACCESSION NUMBER 67613
LOT NUMBER 33

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		180.0	209.4	15.4		

ACCESSION NUMBER 67614
LOT NUMBER 94

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		182.6	197.4	17.0		L
1200		148.4	165.1	11.0		L

ACCESSION NUMBER 67614
LOT NUMBER 94

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		170.6	195.3	19.0		L
70		180.7	196.6	18.0		L
1200		135.7	154.8	14.0		L
1200		143.3	159.6	12.0		L

ACCESSION NUMBER 67614
LOT NUMBER 97

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		179.6	202.2	17.0		L
1200		149.3	165.2	11.0		L

ACCESSION NUMBER 67614
LOT NUMBER 98

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		196.7	207.7	13.0		L
1200		160.6	176.4	13.0		L

Heat Treatment: 1750 F/1 hr + 1325 F/8 hr + 1150 F/8 hr

Ref: 65927, 67602, 67609, 67613, 67614

DMIC

data sheet

Metal or Alloy: Alloy 718

Form: Sheet

Condition: Aged

Alloy Data: Tensile properties

ACCESSION NUMBER 51792
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-110		160.5	212.0	25.0		T
73		163.0	196.0	21.0		T
70		162.5	197.0	21.0		T
350		153.0	191.0	20.0		T
650		141.5	171.5	20.0		T
650		137.5	172.0	23.0		T
800		128.0	180.0	23.0		T
1000		114.0	169.0	24.0		T

ACCESSION NUMBER 51792
LOT NUMBER 2

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-320		229.0	240.5	13.0		T
-110		206.5	232.0	17.0		T
70		190.5	221.0	12.0		T
70		195.5	212.0	13.0		T
350		188.5	205.0	12.0		T
650		179.0	193.5	12.0		T
650		182.0	198.5	13.0		T
1000		165.3	180.5	10.0		T

ACCESSION NUMBER 51792
LOT NUMBER 3

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		197.5	214.5	13.0		T

ACCESSION NUMBER 51792
LOT NUMBER 4

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		193.5	210.5	12.0		T

ACCESSION NUMBER 51792
LOT NUMBER 5

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		142.0	189.0	21.5		T
70		143.0	181.0	16.0		T
70		137.0	180.0	23.0		T

Heat Treatment: 1800 F/1 hr + 1325 F/8 hr

Ref: 51792

ACCESSION NUMBER 63649
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		176.5	219.8	16.0		L
-423		181.1	222.0	13.0		L
-423		173.0	219.0	15.0		L
-423		170.3	214.3	14.0		L
-423		173.5	218.1	15.0		L
-423		172.2	219.5	15.5		L
-423		174.5	217.2	13.5		L
-423		171.3	218.4	15.0		L
-423		171.7	217.0	14.5		L
-423		170.0	212.0	15.0		L
80		149.0	183.5	16.0		L
80		148.4	182.4	17.0		L
80		144.6	180.1	17.0		L
80		146.5	181.3	17.5		L
80		147.3	179.7	16.0		L
80		146.0	180.0	15.0		L
80		144.3	181.1	17.5	40.0	L
80		147.4	181.6	17.5		L
80		147.2	181.6	17.0		L
1000		130.5	153.5	16.5		L
1000		125.9	153.9	16.0		L
1000		127.6	154.3	16.6		L
1000		126.3	154.3	17.5		L
1000		126.7	153.1	17.0		L
1000		128.1	154.0	17.0		L
1200		123.0	150.0	13.0		L
1200		124.0	142.0	10.0		L
1200		128.0	151.0	10.0		L
1200		126.0	152.0	10.0		L
1200		123.0	151.0	10.0		L
1200		121.0	151.0	10.0		L
1200		128.0	151.0	16.0		L
1200		124.0	152.0	16.0		L
1200		120.0	152.0	17.0		L
1200		126.0	151.0	10.0		L
1500		69.4	72.5	14.0		L
1500		66.4	73.3			L
1500		69.7	71.0			L
1500		67.7	72.5			L
1500		67.6	72.1	14.0		L

Heat Treatment: 1750 F/1 hr + 1400 F/10 hr + 1300 F/15 hr

Ref: 63649

ACCESSION NUMBER 61323
LOT NUMBER 2

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
80		173.5	207.5	17.3		L
80		175.0	206.0	18.0		T
800		156.7	182.5	20.3		L
800		157.5	179.7	21.0		T
1000		153.0	177.2	21.5		L
1000		151.5	176.4	21.0		T
1200		141.9	159.4	11.0		L
1200		141.7	160.0	10.0		T

ACCESSION NUMBER 61323
LOT NUMBER 3

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
80		176.5	204.0	20.5		L
80		168.0	198.5	21.0		T
800		156.0	174.2	19.3		L
800		150.0	169.0	17.5		T
1000		150.2	169.3	18.0		L
1000		148.0	163.0	19.0		T
1200		143.3	157.0	6.5		L
1200		136.5	142.5	7.5		T

Condition: Cold rolled 20% then heat treated as follows:

Lot	Heat Treatment
2	Solution treated at 1750 F, then aged 1325 F/8 hr + 1150 F/10 hr
3	Solution treated at 1950 F/10 hr aged 1350 F/8 hr + 1150 F/12 hr

Ref: 61323

DMIC data sheet

ACCESSION NUMBER 51792
LOT NUMBER 1

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-110	20.0	195.5				
70	20.0	165.0				
70	23.0	170.0				
650	23.0	150.5				
650	23.0	143.0				
800	20.0	150.0				
1000	20.0	143.0				

ACCESSION NUMBER 51792
LOT NUMBER 2

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-320	23.0	230.5				
-110	20.0	[illegible]				
70	20.0	190.5				
70	23.0	190.0				
350	20.0	179.7				
650	23.0	173.5				
650	20.0	172.0				
800	20.0	169.0				
1000	20.0	166.5				

ACCESSION NUMBER 51792
LOT NUMBER 3

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
70	20.0	205.5				

ACCESSION NUMBER 51792
LOT NUMBER 5

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
72	20.0	201.5				

Heat Treatment [illegible]

Ref 51792

ACCESSION NUMBER 55290
LOT NUMBER 1

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	303.0				
-423	6.3	314.0				
-423	[illegible]	315.0				
-423	6.3	308.0				
-423	6.3	305.0				
-423	6.3	307.0				
-423	6.3	292.0				
-423	6.3	301.0				
-423	6.3	303.0				
-423	6.3	310.0				
-320	6.3	296.0				
-320	6.3	285.0				
-320	6.3	299.0				
-320	6.3	291.0				
-320	6.3	299.0				
-320	6.3	286.0				
-320	6.3	285.0				
-320	6.3	291.0				
-320	6.3	263.0				
-320	6.3	280.0				
-100	6.3	259.0				
-100	6.3	260.0				
-100	6.3	268.0				
-100	6.3	266.0				
-100	6.3	265.0				
-100	6.3	262.0				
-100	6.3	262.0				
-100	6.3	263.0				
-100	6.3	261.0				
-100	6.3	261.0				
75	6.3	248.0				
75	6.3	246.0				
75	6.3	249.0				
75	6.3	249.0				
75	6.3	249.0				
75	6.3	243.0				
75	6.3	249.0				
75	6.3	249.0				
75	6.3	250.0				
75	6.3	250.0				

ACCESSION NUMBER 61090
LOT NUMBER 1

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	3.5	184.1				
-423	3.5	179.4				
-423	3.5	175.0				
-320	3.5	168.0				
-320	3.5	167.1				
-320	3.5	156.2				
72	3.5	121.2				
72	3.5	121.1				
72	3.5	121.0				

Condition Annealed

Ref 55290 and 61090

DMIC data sheet

Base Metal: Nickel

Metal or Alloy: Alloy 718

Form: Sheet

Condition: Aged

Alloy Data: Notched Tensile and Rupture Properties

ACCESSION NUMBER 61323
LOT NUMBER 2

NOTCHED TENSILE AND RUPTURE DATA

TEMP., F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURA-TION HOURS	RUPTURE: RED. IN AREA PER CENT
75	20.0	187.0				
75	20.3	180.0				
800	20.0	170.0		140.0	1700.0	
800	20.0	168.5		150.0	849.0	
1000	2.3			160.0	15.0	
1000	2.3			150.0	95.9	
1000	2.3			140.0	375.0	
1000	2.3			130.0	1305.6	
1000	6.0			160.0	41.0	
1000	6.0			150.0	120.0	
1000	6.0			140.0	360.0	
1000	6.0			130.0	4078.0	
1000	6.0			120.0	1347.0	
1000	20.0	132.0		100.0	6.9	
1000	20.0	142.5		100.0	20.0	
1000	20.0			80.0	268.0	
1000	20.0			75.0	321.0	
1000	20.0			70.0	395.0	
1000	20.0			65.0	1771.0	
1000	20.0			90.0	55.7	
1000	20.0			120.0	6.6	
1000	20.0			70.0	371.0	
1000	20.0			75.0	209.0	
1000	20.0			70.0	794.0	
1000	20.0			66.0	1541.0	
1200	2.3			90.0	168.0	
1200	2.3			80.0	470.0	
1200	2.3			70.0	301.0	
1200	2.3			65.0	1312.0	
1200	6.0			90.0	103.0	
1200	6.0			80.0	174.0	
1200	6.0			70.0	631.0	
1200	6.0			65.0	1317.0	
1200	20.0	138.0		80.0	11.2	
1200	20.0	139.2		70.0	21.2	
1200	20.0			60.0	1033.3	
1200	20.0			80.0	7.2	
1200	20.0			70.0	276.0	
1200	20.0			60.0	682.0	
1200	20.0			55.0	1207.0	

ACCESSION NUMBER 61323
LOT NUMBER 3

NOTCHED TENSILE AND RUPTURE DATA

TEMP., F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURA-TION HOURS	RUPTURE: RED. IN AREA PER CENT
75	20.0	196.6				
75	20.0	195.6				
800	20.0	168.0		157.0	1578.0	
800	20.0	167.5		168.0	302.0	
800	20.0			155.0	1079.0	
800	20.0			150.0	2054.0	
800	20.0			155.0	1657.0	
800	20.0			150.0	1427.0	
1000	2.3			150.0	80.5	
1000	2.3			145.0	67.3	
1000	2.3			140.0	267.0	
1000	2.3			130.0	79.2	
1000	2.5			130.0	132.0	
1000	6.0			120.0	155.0	
1000	6.0			110.0	197.0	
1000	6.0			100.0	501.0	
1000	6.0			90.0	981.0	
1000	20.0	166.5		[illegible]	75.6	
1000	20.0	159.5		100.0	134.[illegible]	
1000	20.0			90.0	56.1	
1000	20.0			80.0	96.7	
1000	20.0			75.0	333.6	
1000	20.0			70.0	641.3	
1000	20.0			65.0	501.6	
1000	20.0			90.0	214.0	
1000	20.0			80.0	590.0	
1000	20.0			75.0	1031.0	
1200	2.3			60.0	304.0	
1200	2.3			50.0	911.0	
1200	6.0			50.0	40.2	
1200	6.0			45.0	167.0	
1200	6.0			40.0	435.0	
1200	6.0			30.0	2400.0	
1200	20.0	151.9		50.0	16.1	
1200	20.0	148.4		70.0	4.3	
1200	20.0			60.0	6.5	
1200	20.0			65.0	8.5	
1200	20.0			30.0	1771.0	
1200	20.0			70.0	2.5	
1200	20.0			60.0	2.7	
1200	20.0			50.0	60.5	
1200	20.0			40.0	2639.0	

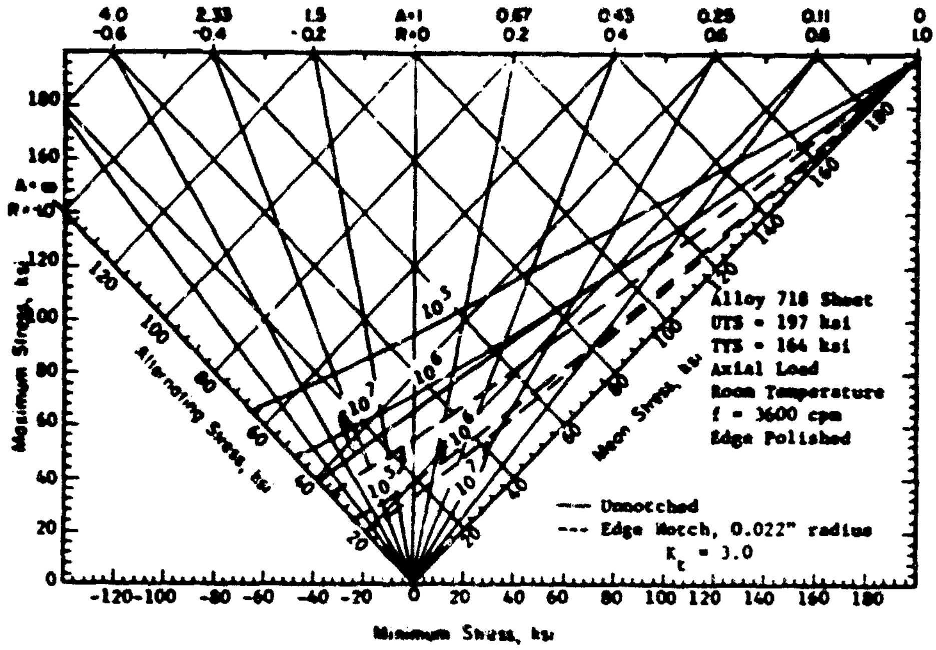
Condition: Cold rolled 20% then heat treated as follows

Lot	Heat Treatment
2	Solution treated at 1750 F, then aged 1325 F/8 hr + 1150 F/10 hr
3	Solution treated at 1950 F, then aged 1350 F/8 hr + 1150 F/12 hr

Ref 61323

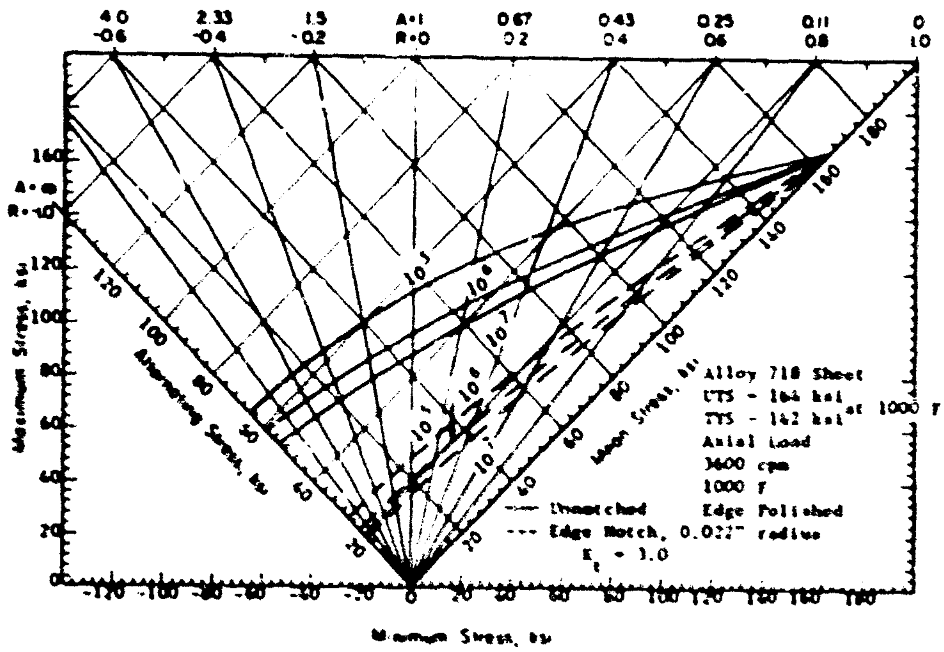
DMIC

data sheet



CONSTANT-LIFE FATIGUE DIAGRAM* FOR ALLOY 718 SHEET TESTED AT ROOM TEMPERATURE. (UNNOTCHED AND EDGE-NOTCHED).

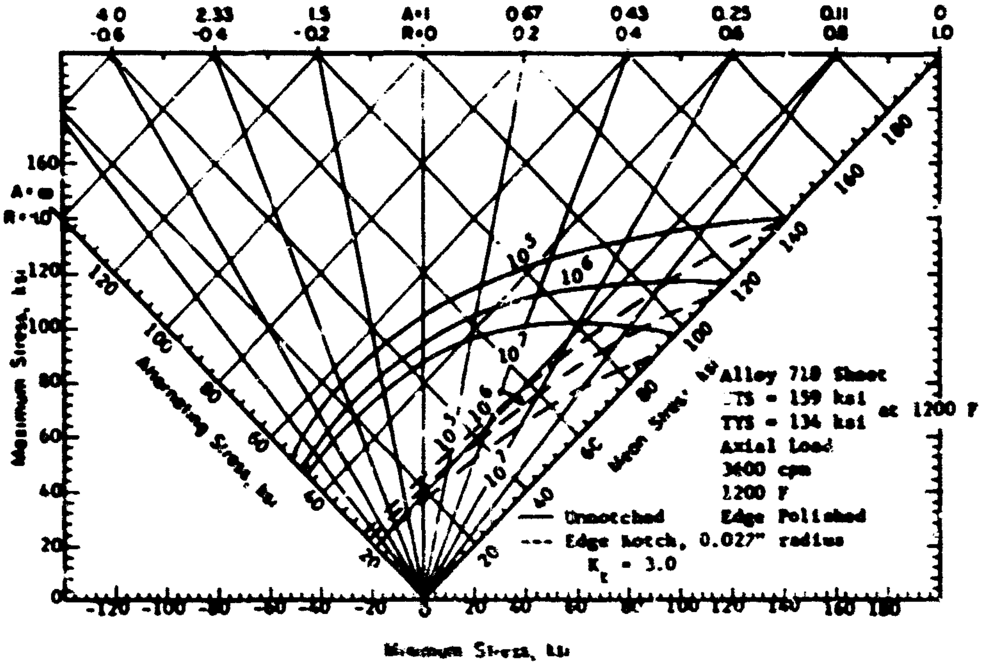
Ref: 65927



CONSTANT-LIFE FATIGUE DIAGRAM* FOR ALLOY 718 SHEET TESTED AT 1000 F. (UNNOTCHED AND EDGE-NOTCHED)

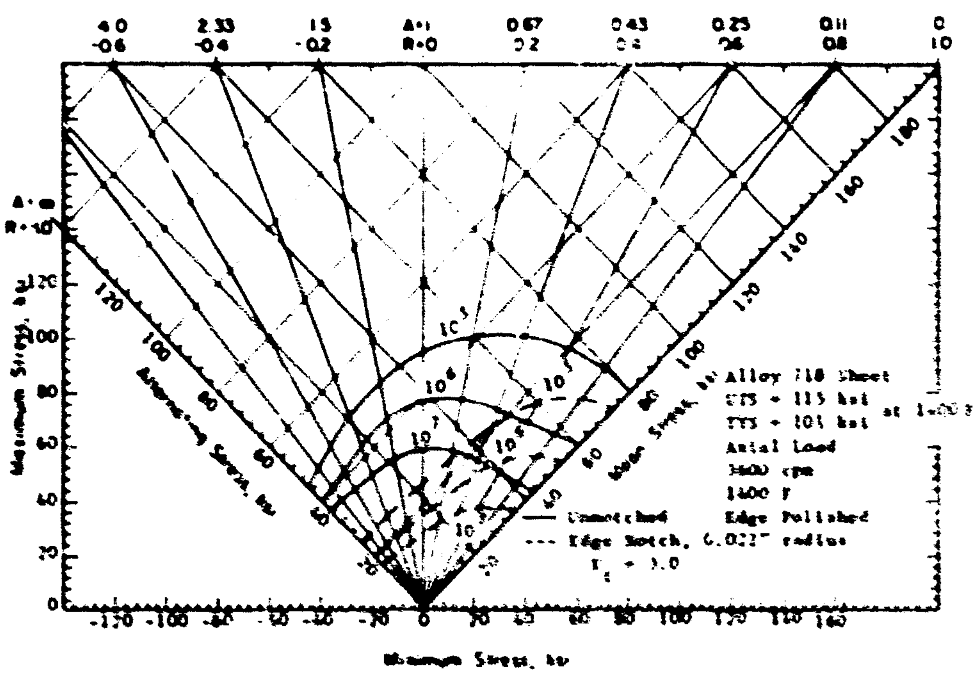
Ref: 65927

*The Use of These Diagrams is Described in The Appendix.



CONSTANT-LIFE FATIGUE DIAGRAM* FOR ALLOY 718 SHEET TESTED AT 1200 F.
(UNNOTCHED AND EDGE-NOTCHED).

Ref: 65927



CONSTANT-LIFE FATIGUE DIAGRAM* FOR ALLOY 718 SHEET TESTED AT 1400 F.
(UNNOTCHED AND EDGE-NOTCHED)

Ref 65927

*The Use of These Diagrams is Described in The Appendix

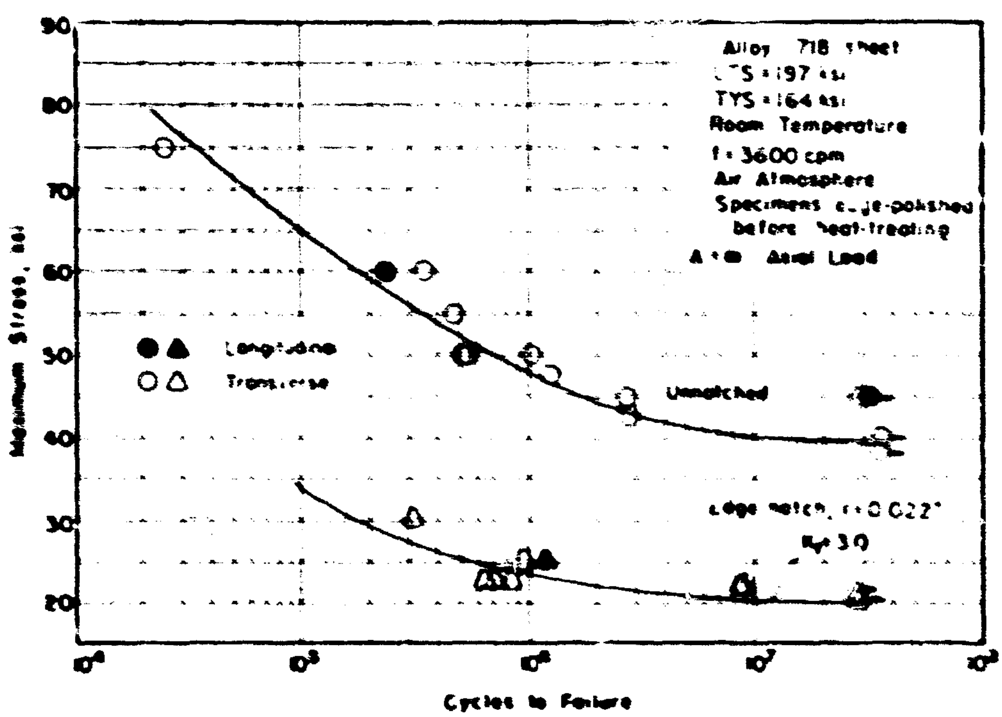
DMIC data sheet

Fatigue data for Alloy 718 sheet at room temperature and stress ratio, A = ∞ and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	38.0	34,960,000 DNF*
"	"	40.0	35,800,000 DNF
"	"	42.5	2,976,000
"	"	45.0	2,862,000
"	"	45.0	29,560,000
"	"	47.5	1,252,000
"	"	50.0	50[illegible],000
"	"	50.0	525,000
"	"	50.0	1,037,000
"	"	55.0	480,000
"	"	60.0	346,000
"	"	75.0	24,000
"	L	45.0	30,180,000 DNF
"	L	60.0	227,000
3.0	T	20.0	29,800,000 DNF
3.0	"	21.0	29,890,000 DNF
"	"	22.0	8,996,000
"	"	22.0	9,016,000
"	"	23.5	637,000
"	"	23.5	709,000
"	"	23.5	849,000
"	"	25.0	966,000
"	"	30.0	307,000
"	L	25.0	1,190,000

*Did not fail



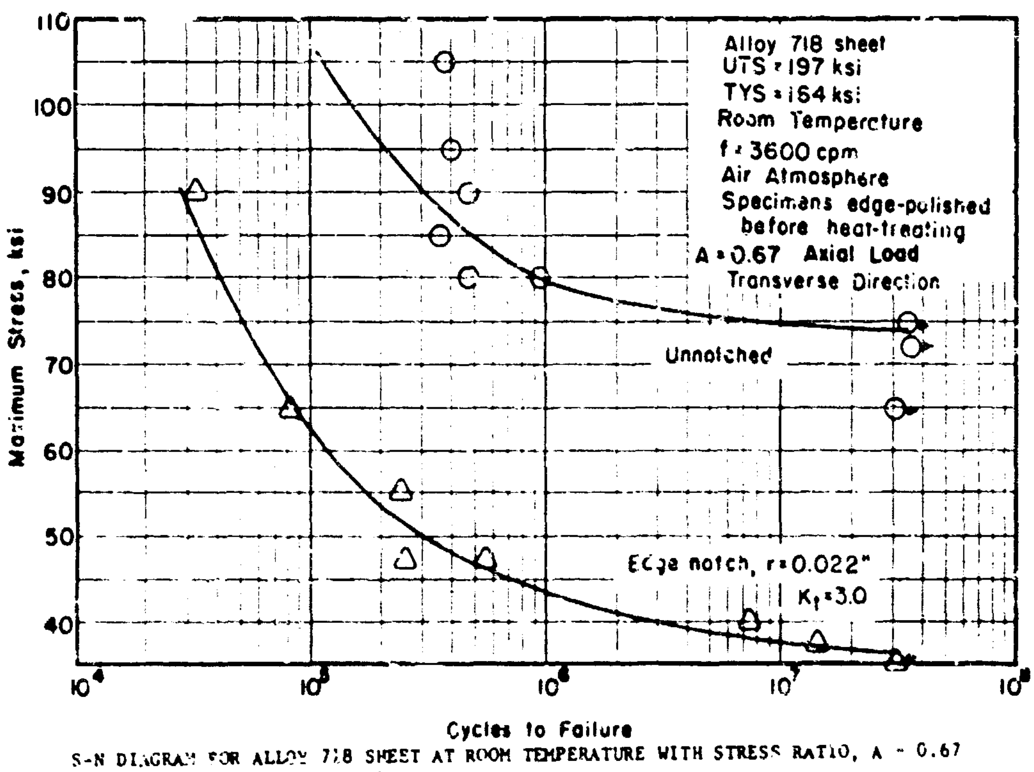
S-N DIAGRAM FOR ALLOY 718 SHEET AT ROOM TEMPERATURE WITH STRESS RATIO, A = ∞ (unnotched and edge-notched)

Fatigue data for Alloy 718 sheet at room temperature and stress ratio, A = 0.67 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	65.0	30,770,000 DNF*
"	"	72.0	36,100,000 DNF
"	"	75.0	35,340,000 DNF
"	"	80.0	482,000
"	"	80.0	948,000
"	"	85.0	352,000
"	"	90.0	482,000
"	"	95.0	400,000
"	"	105.0	389,000
"	"	120.0	147,000
3.0	"	35.0	30,670,000 DNF
"	"	37.5	15,940,000
"	"	40.0	7,417,000
"	"	47.5	243,000
"	"	47.5	587,000
"	"	55.0	242,000
"	"	65.0	82,000
"	"	90.0	32,000

*Did Not Fail



S-N DIAGRAM FOR ALLOY 718 SHEET AT ROOM TEMPERATURE WITH STRESS RATIO, A = 0.67 (unnotched and edge-notched)

DMIC data sheet

Fatigue data for Alloy 718 sheet[1] at room temperature and stress ratio A = 0.33 and heat treated as follows:

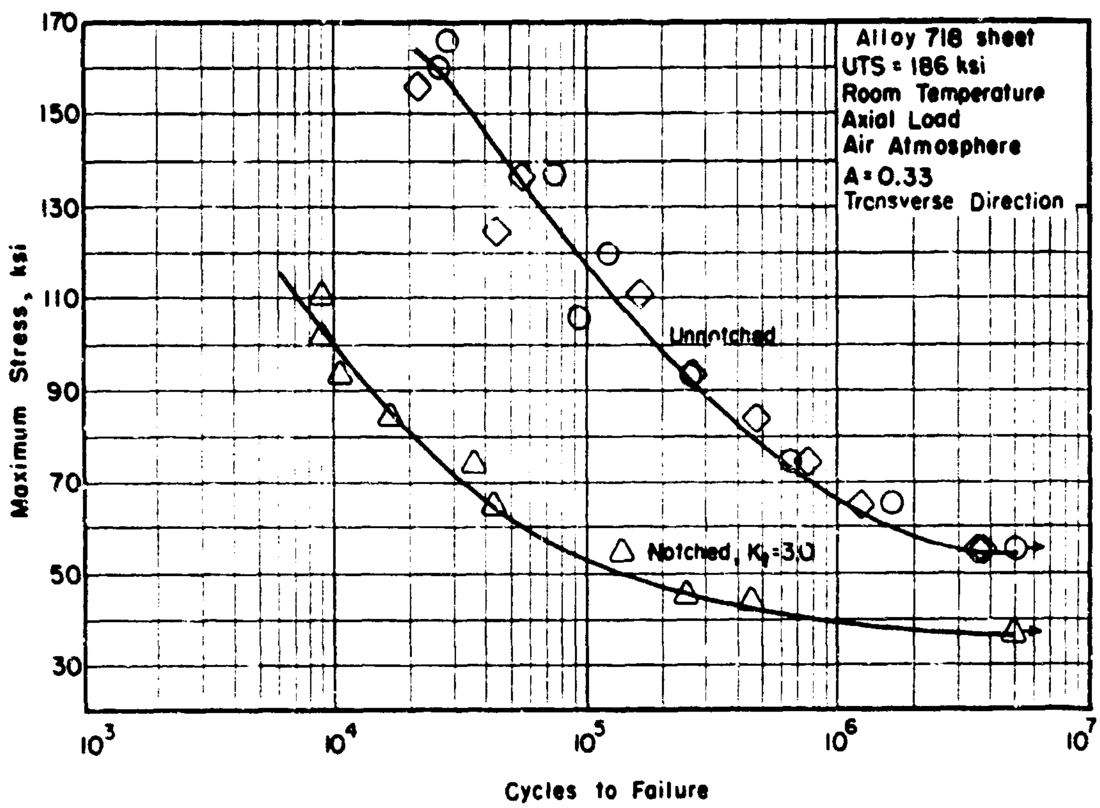
Solution treated 1600 F (1/2 hr) A.C.
Aged 1325 F (16 hr) A.C.

Ref: 61646

Stress Concentration, K_t	Sheet Thickness	Maximum Stress (ksi)	Cycles to Failure
1.0	.063	120.0	113,000
"	"	138.5	75,000
"	"	166.2	29,000
"	"	184.7	9,000
"	"	159.4	27,000
"	"	92.3	256,000
"	"	73.9	676,000
"	"	64.6	1,789,000
"	"	55.4	5,000,000 DNF*
"	"	106.2	92,000
3.0	"	83.1	17,000
"	"	101.6	9,000
"	"	64.6	42,000
"	"	46.2	230,000
"	"	92.3	11,000
"	"	36.9	5,000,000 DNF
"	"	55.4	124,000
"	"	73.9	37,000
"	"	42.5	437,000
"	"	110.8	9,000
1.0	0.125	92.3	287,000
"	"	138.5	55,000
"	"	110.8	157,000
"	"	73.9	768,000
"	"	83.1	462,000
"	"	123.7	42,000
"	"	64.6	1,289,000
"	"	55.4	3,757,000
"	"	157.0	21,000
"	"	55.4	3,445,000

*Did Not Fail

(1) UTS = 0.063 sheet - 183.8 ksi
0.125 sheet = 176.5 ksi



S-N DIAGRAM FOR ALLOY 718 SHEET AT ROOM TEMPERATURE WITH STRESS RATIO, A= 0.33 (notched and unnotched)

Ref: 61646

DMIC

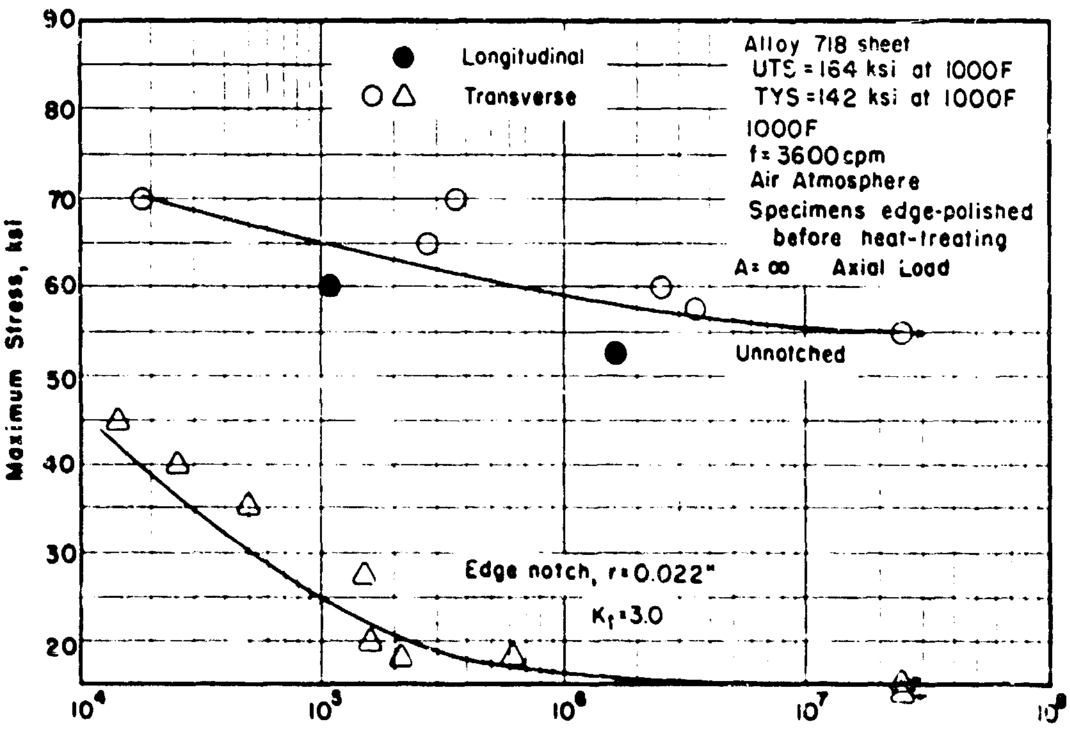
data sheet

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio $A = \infty$ and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	55.0	24,040,000 DNF*
"	"	58.0	3,447,000
"	"	60.0	2,439,000
"	"	65.0	289,000
"	"	70.0	9,000
"	"	70.0	372,000
"	L	52.5	1,747,000
"	"	60.0	108,000
3.0	T	18.0	24,270,000 DNF
"	"	20.0	24,670,000 DNF
"	"	23.0	201,000
"	"	23.0	607,000
"	"	27.5	151,000
"	"	35.0	50,000
"	"	40.0	26,000
"	"	45.0	14,000
"	L	25.0	151,000

*Did Not Fail



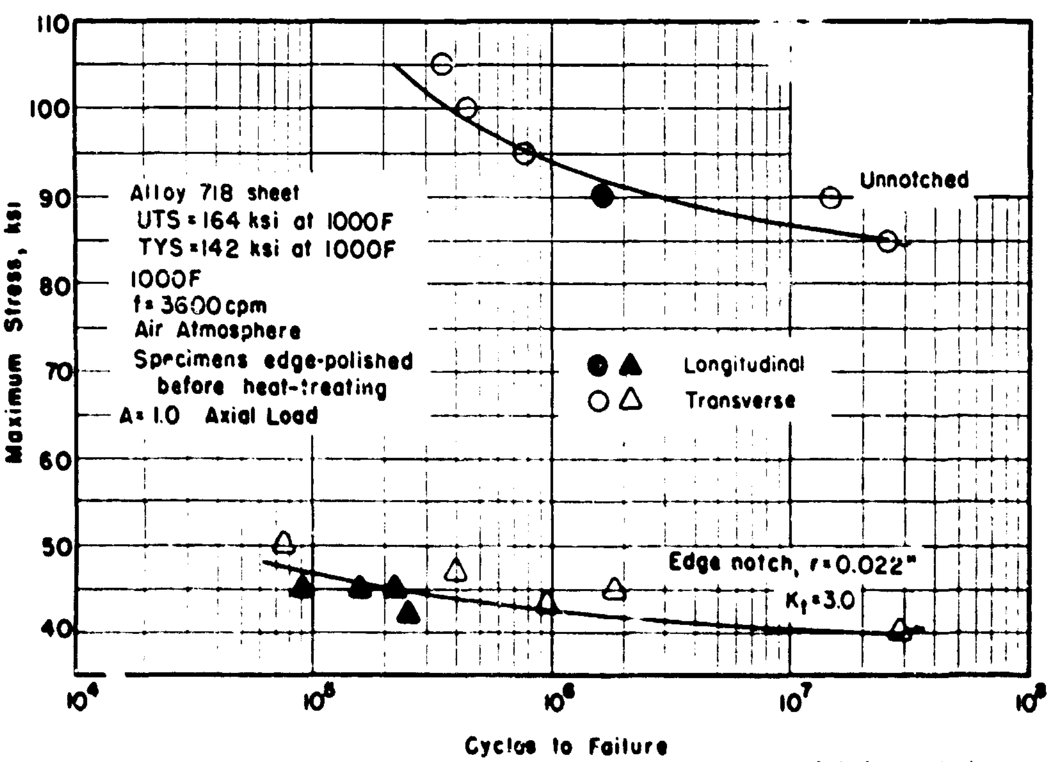
S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO, $A = \infty$ (unnotched and edge-notched)

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio A = 1.0 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	85.0	25,120,000 DNF*
"	"	90.0	14,070,000
"	"	95.0	775,000
"	"	100.0	456,000
"	"	105.0	349,000
"	L	90.0	1,659,000
3.0	T	40.0	29,520,000
"	"	43.0	933,000
"	"	45.0	1,909,000
"	"	47.0	400,000
"	"	50.0	76,000
"	L	42.0	158,000
"	"	45.0	91,000
"	"	45.0	149,000
"	"	45.0	207,000

*Did Not Fail



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO, A = 1.0 (unnotched and edge-notched)

DMIC

data sheet

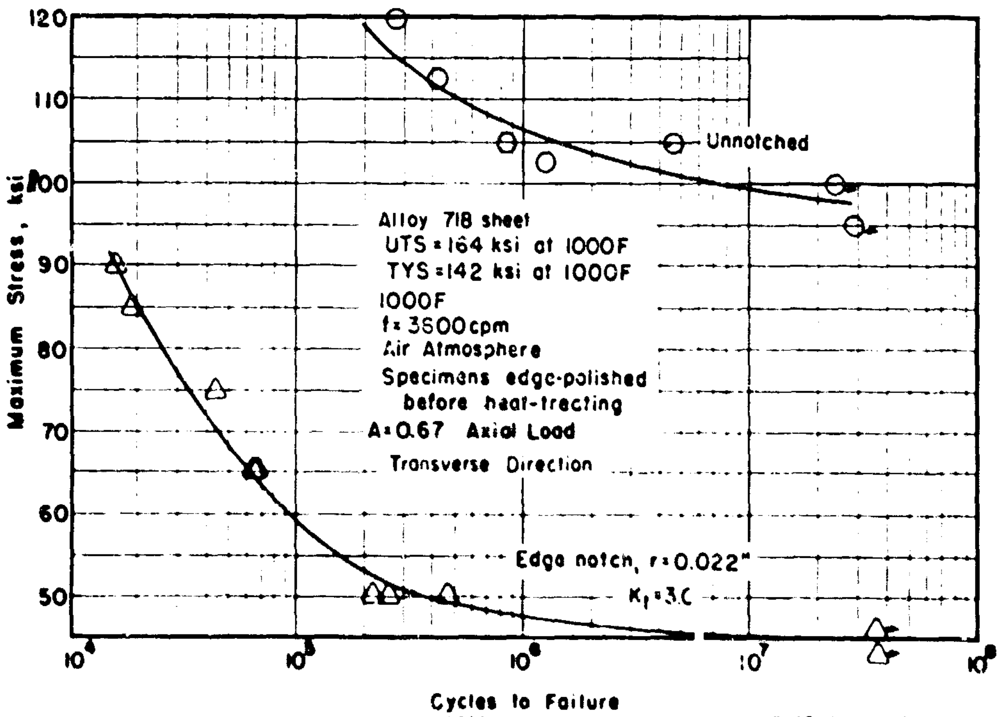
Base Material: Nickel IV-85
Metal or Alloy: Alloy 718
Form: Sheet
Condition: Aged
Alloy Data: Fatigue properties

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio, A = 0.67 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	95.0	29,860,000 DNF*
"	"	100.0	22,790,000
"	"	102.5	1,214,000
"	"	105.0	849,000
"	"	105.0	4,636,000
"	"	112.5	403,000
"	"	120.0	290,000
3.0	"	35.0	24,520,000 DNF
"	"	42.5	30,170,000 DNF
"	"	46.0	35,210,000 DNF
"	"	50.0	210,000
"	"	50.0	248,000
"	"	50.0	480,000
"	"	65.0	65,000
"	"	65.0	67,000
"	"	75.0	43,000
"	"	85.0	19,000
"	"	90.0	15,000

*Did Not Fail



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO, A = 0.67 (unnotched and edge-notched)

DMIC **data sheet**

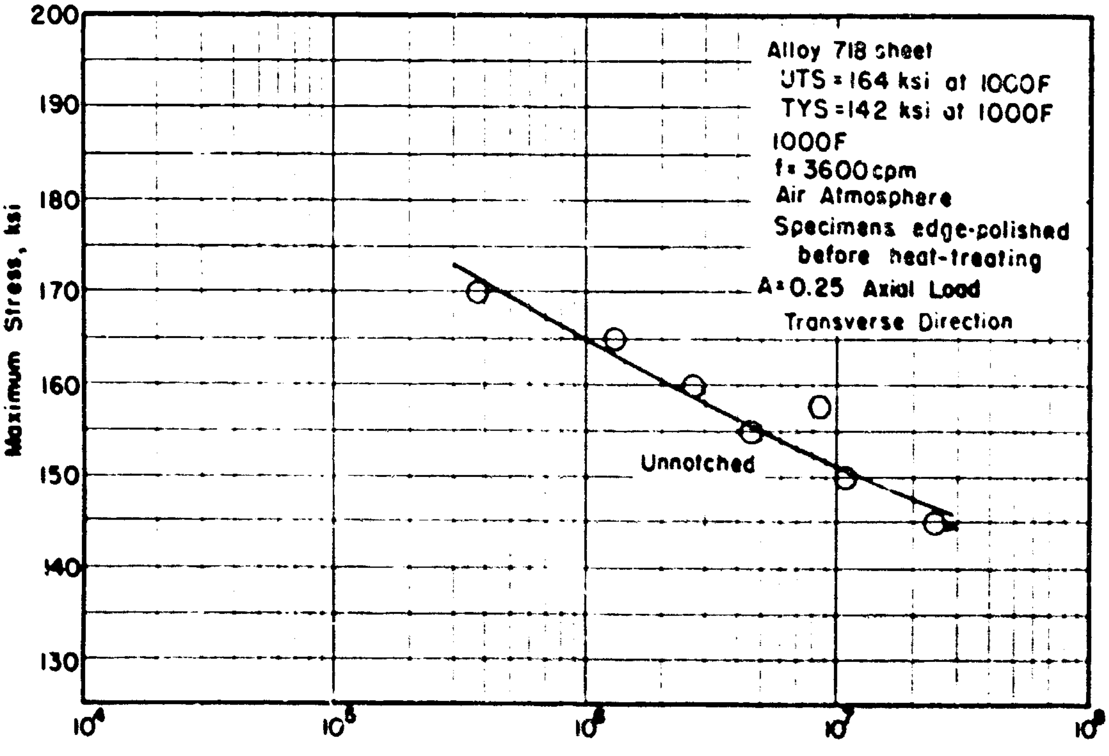
Base Material:	Nickel
Metal or Alloy:	Alloy 718
Form:	Sheet
Condition:	Aged
Alloy Data:	Fatigue properties

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio, A = 0.25 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Fracture
1.0	T	145.0	24,120,000 DNF*
"	"	150.0	10,490,000
"	"	155.0	4,527,000
"	"	157.5	8,554,000
"	"	160.0	2,888,000
"	"	165.0	1,331,000
"	"	170.0	381,000

*Did Not Fail



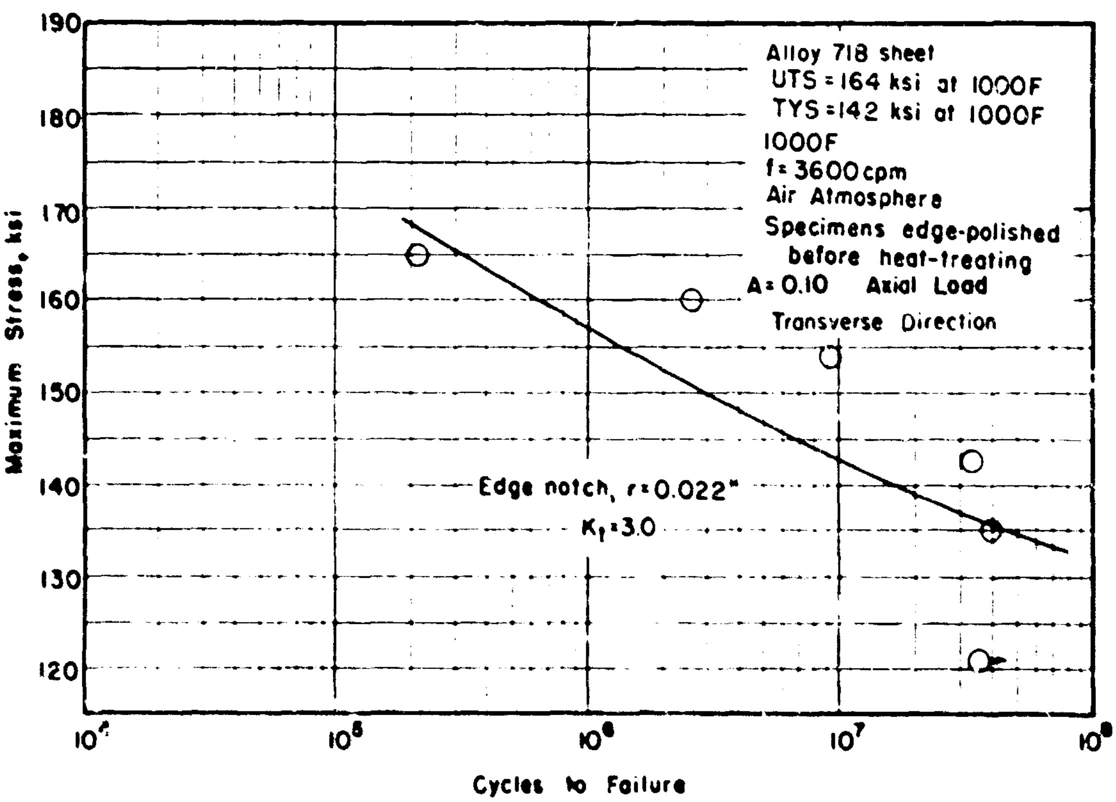
S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO, A = 0.25 (unnotched)

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio, A = 0.10 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
3.0	T	121.0	35,760,000 DNF*
"	"	135.0	39,990,000
"	"	143.0	32,860,000
"	"	154.0	9,148,000
"	"	160.0	2,521,000
"	"	165.0	205,000

*Did Not Fail



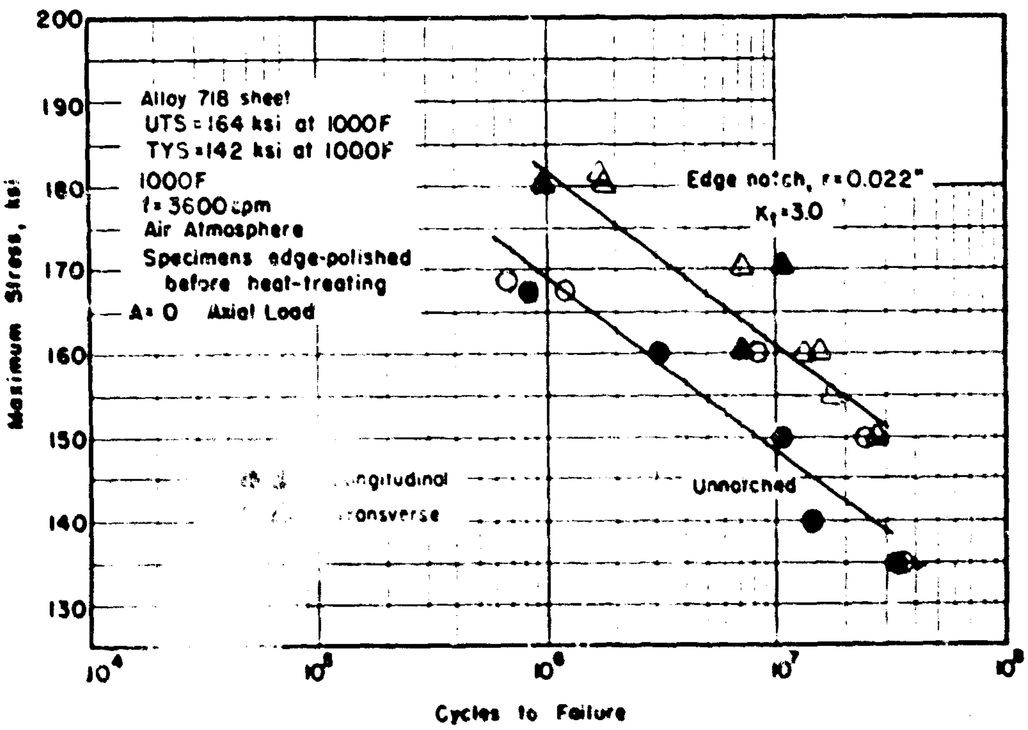
S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO A = 0.10 (edge-notched)

Fatigue data for Alloy 718 sheet at 1000 F and stress ratio A = 0 (stress rupture) and heat treated as per AMS 5596 A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Time to Rupture Hours	Time to Rupture Equivalent Cycles
1.0	T	135.0	163.3	35,272,000 DNF*
"	"	150.0	114.2	24,667,000
"	"	160.0	38.4	8,294,000
"	"	167.5	5.6	1,209,000
"	"	168.5	3.2	691,000
"	L	135.0	156.2	33,139,000
"	"	140.0	72.6	15,681,000
"	"	150.0	53.0	11,448,000
"	"	160.0	14.1	3,045,000
"	"	167.5	3.8	821,000
3.0	T	150.0	131.1	28,317,000
"	"	155.0	86.6	18,705,000
"	"	160.0	62.4	13,478,000
"	"	160.0	75.3	16,264,000
"	"	170.0	33.2	7,171,000
"	"	180.0	8.5	1,836,000
"	"	181.5	7.9	1,706,000
"	L	160.0	33.9	7,322,000
"	"	170.0	52.9	11,426,000
"	"	180.0	4.6	993,000

*Did Not Fail



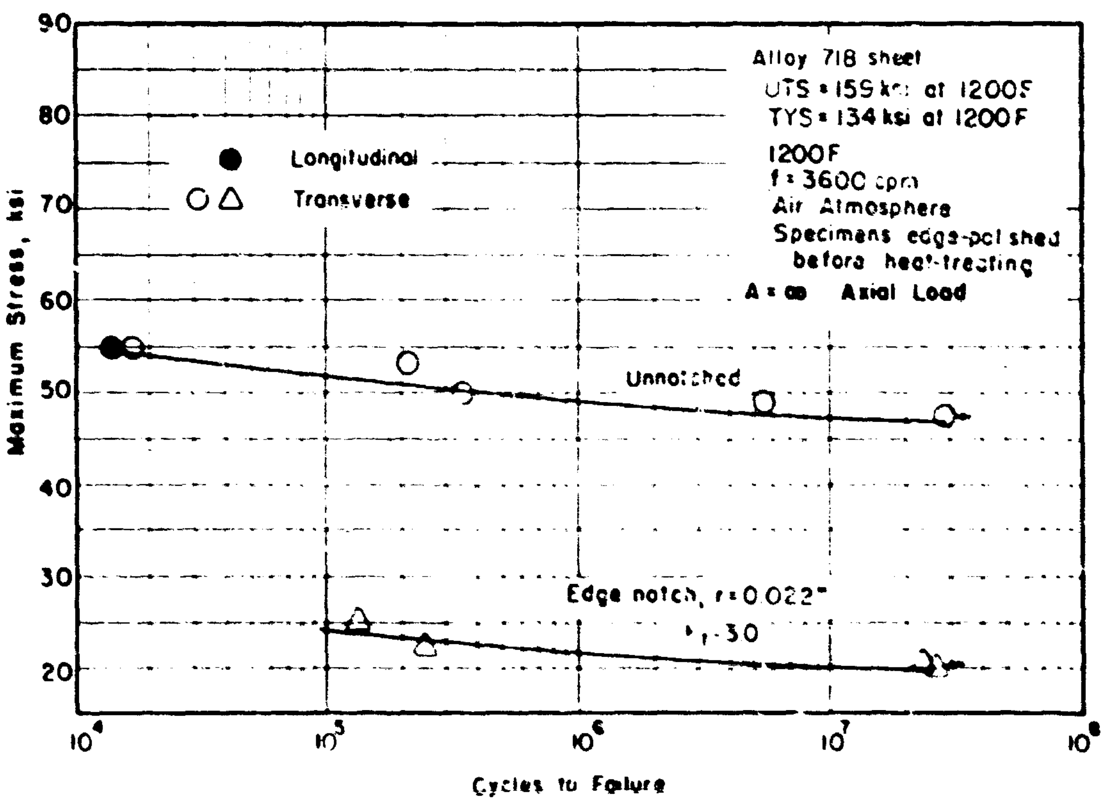
S-N DIAGRAM FOR ALLOY 718 SHEET AT 1000 F WITH STRESS RATIO, A = 0 (unnotched and edge-notched).

Fatigue data for Alloy 718 sheet at 1200 F and stress ratio, A = ~ and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	47.5	29,430,000 DNF*
"	"	49.0	5,491,000
"	"	50.0	343,000
"	"	52.5	205,000
"	"	55.0	17,000
"	"	62.5	4,000
"	"	65.0	2,000
"	L	55.0	14,000
3.0	T	20.0	26,240,000 DNF
"	"	21.0	23,250,000
"	"	22.5	233,000
"	"	25.0	130,000

*Did Not Fail



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1200 F WITH STRESS RATIO, A = ∞ (unnotched and edge-notched)

DMIC data sheet

Base Material: Nickel

Metal or Alloy: Alloy 718

Form: Sheet

Condition: Aged

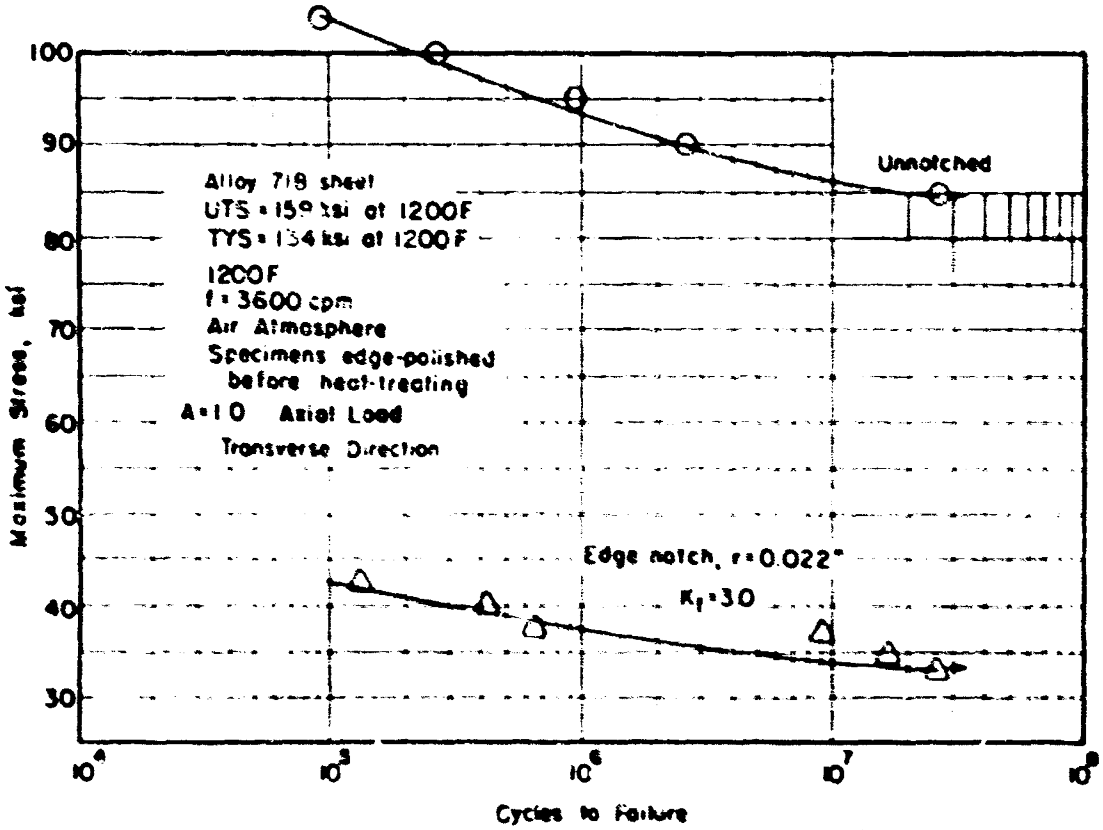
Alloy Data: Fatigue properties

Fatigue data for Alloy 718 sheet at 1200 F and stress ratio, A = 1.0 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	85.0	29,250,000 DNF*
"	"	90.0	2,603,000
"	"	95.0	942,000
"	"	100.0	766,000
"	"	105.0	91,000
3.0	"	33.0	25,280,000 DNF
"	"	35.0	18,090,000
"	"	37.0	9,204,000
"	"	37.5	659,000
"	"	40.0	419,000
"	"	42.5	133,000

*Did Not Fail



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1200 F WITH STRESS RATIO, A = 1.0 (unnotched and edge-notched)

DMIC

data sheet

Nickel

Alloy 718

Sheet

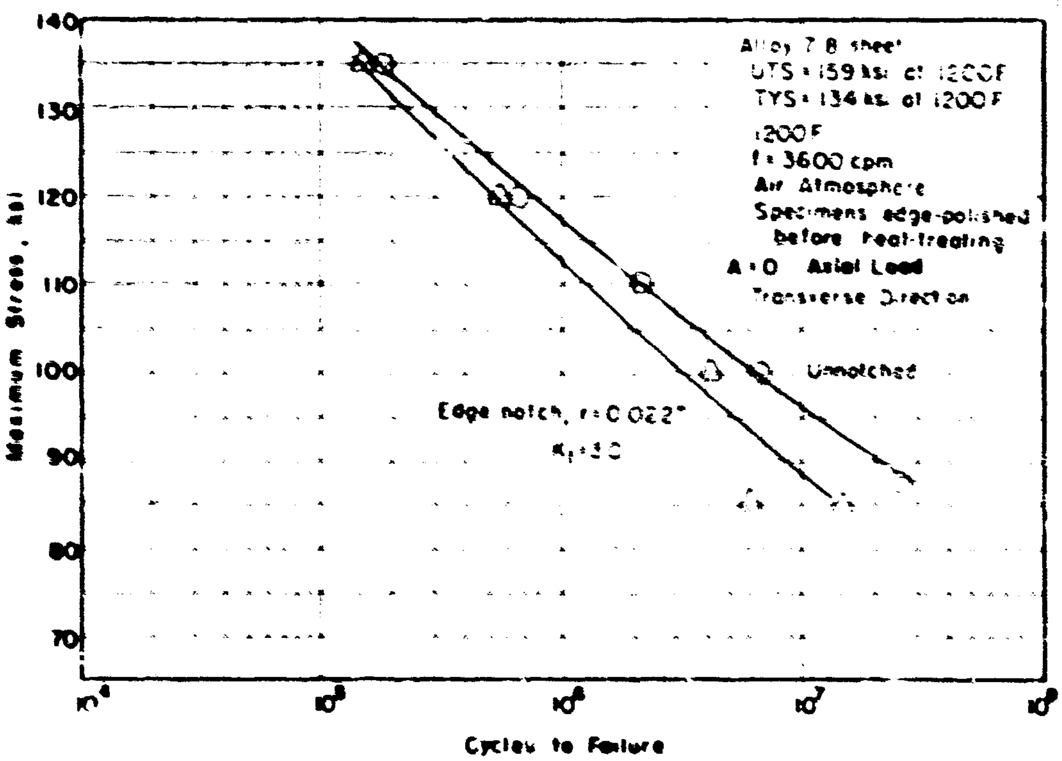
Aged

Fatigue properties

Fatigue data for Alloy 718 sheet at 1200 F and stress ratio A = 0 (stress rupture) and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Time to Rupture: Hours	Time to Rupture: Equivalent Cycles
1.0	T	87.5	117.8	25,444,000
"	"	100.0	31.4	6,782,000
"	"	110.0	9.6	2,073,000
"	"	120.0	3.1	669,000
"	"	135.0	0.87	19[illegible],000
3.0	"	85.0	28.0	6,048,000
"	"	85.0	73.4	15,854,000
"	"	100.0	19.0	4,104,000
"	"	120.0	2.6	561,000
"	"	135.0	0.67	[illegible]50,000



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1200 F WITH STRESS RATIO, A = 0 (unnotched and edge-notched)

DMIC **data sheet**

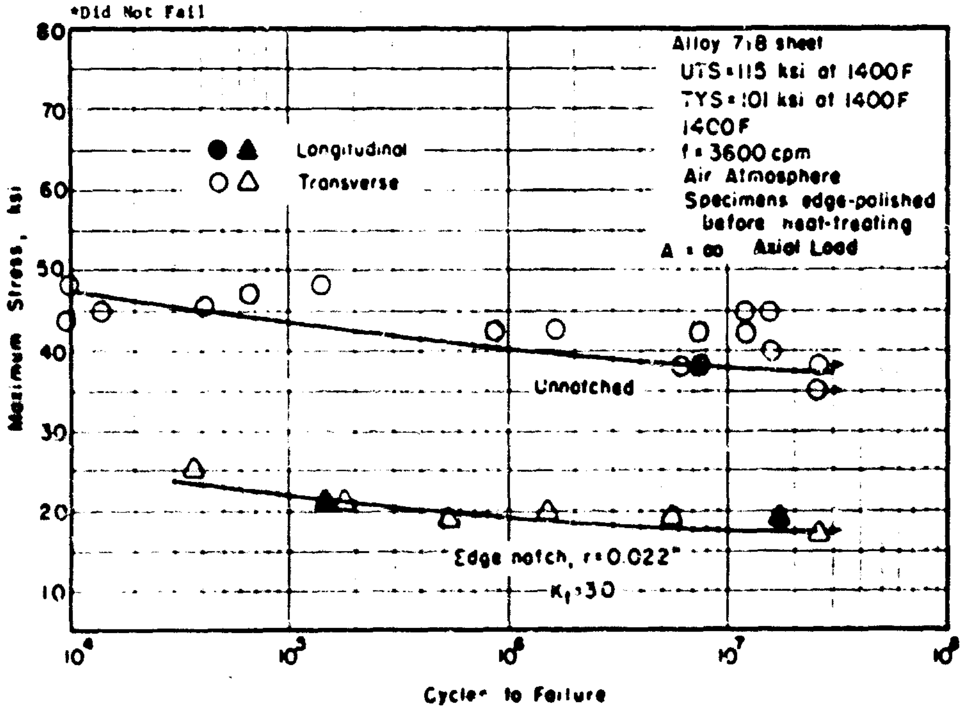
Base Material: Nickel
Metal or Alloy: Alloy 718
Form: Sheet
Condition: Aged
Alloy Data: Fatigue properties
p. 16 of 20

Fatigue data for Alloy 718 she: at 1400 F and stress ratio, A = ∞ and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	35.0	24,600,000 DNF*
"	"	38.0	6,169,000
"	"	38.0	26,150,000 DNF
"	"	40.0	16,150,000
"	"	42.0	871,000
"	"	42.0	7,610,000
"	"	42.5	1,795,000
"	"	42.5	12,570,000
"	"	44.0	9,000
"	"	45.0	14,000
"	"	45.0	12,000,000
"	"	45.0	15,[illegible]0,000
"	"	46.0	41,000
"	"	47.0	68,000
"	"	48.0	9,000
"	"	48.0	130,000
"	L	38.0	7,570,000
3.0	T	17.5	25,100,000 DNF
"	"	19.0	514,000
"	"	19.0	5,577,000
"	"	20.0	1,484,000
"	"	21.0	186,000
"	"	25.0	36,000
"	L	19.0	18,200,000
"	"	21.0	151,000

*Did Not Fail



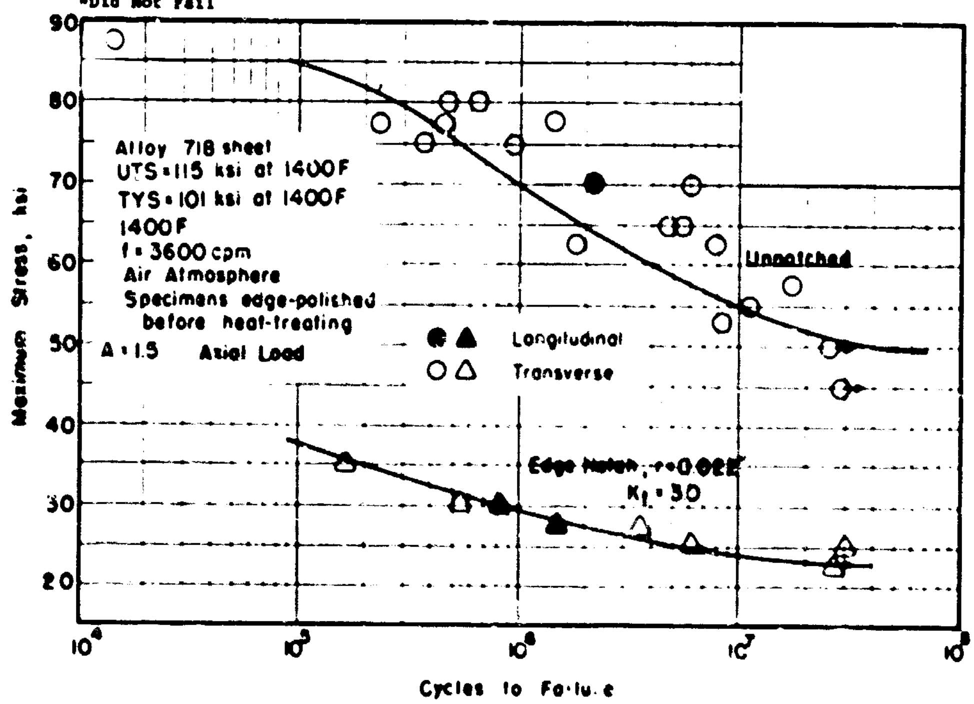
S-N DIAGRAM FOR ALLOY 718 SHEET AT 1400 F WITH STRESS RATIO, A= ∞ (unnotched and edge-notched)

Fatigue data for Alloy 718 sheet at 1400 F and stress ratio. A = 1.5 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	45.0	29,550,000 DNF*
"	"	50.0	25,180,000 DNF
"	"	53.0	8,240,000
"	"	55.0	10,780,000
"	"	57.5	17,540,000
"	"	62.5	1,929,000
"	"	62.5	7,962,000
"	"	65.0	4,776,000
"	"	65.0	5,467,000
"	"	70.0	6,055,000
"	"	75.0	382,000
"	"	75.0	920,000
"	"	77.5	227,000
"	"	77.5	452,000
"	"	77.5	1,413,000
"	"	80.0	493,000
"	"	80.0	659,000
"	"	87.5	14,000
"	L	70.0	2,132,000
3.0	T	22.5	26,320,000 DNF
"	"	25.0	6,178,000
"	"	25.0	30,120,000
"	"	27.5	3,779,000
"	"	30.0	531,000
"	"	35.0	166,000
"	L	27.5	1,354,000
"	"	30.0	810,000

*Did Not Fail

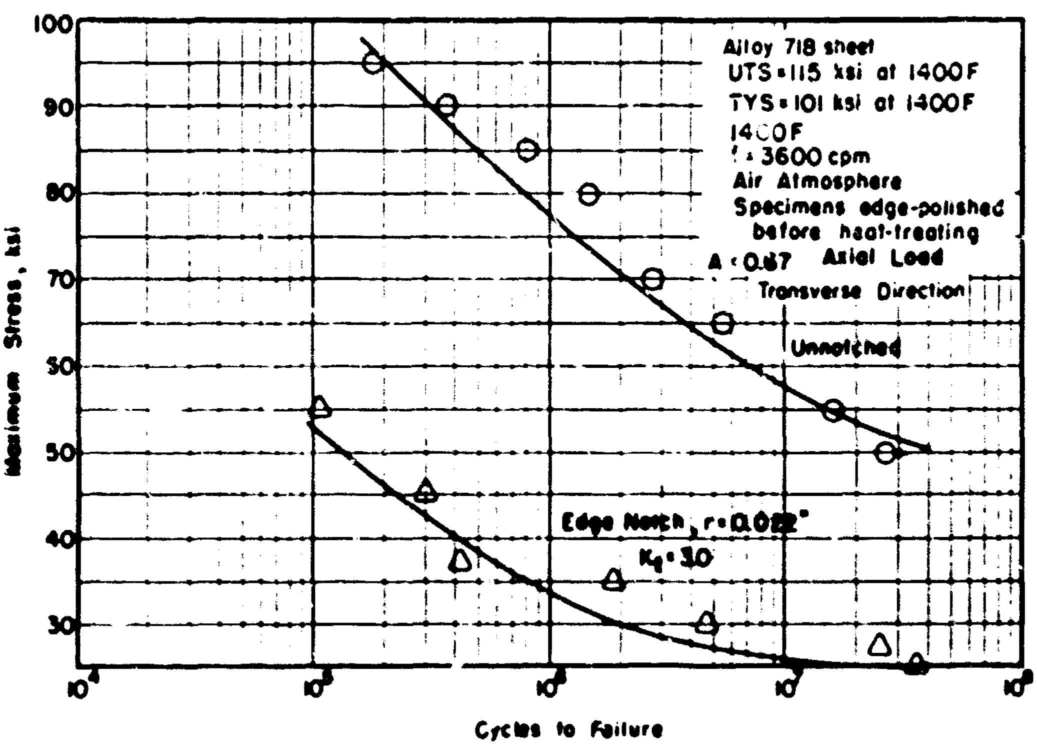


S-N DIAGRAM FOR ALLOY 718 SHEET AT 1400 F WITH STRESS RATIO, A = 1.5 (unnotched and edge-notched)

Fatigue data for Alloy 718 sheet at 1400 F and stress ratio, A = 0.67 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	50.0	26,680,000
"	"	55.0	16,760,000
"	"	65.0	5,424,000
"	"	70.0	2,823,000
"	"	80.0	1,454,000
"	"	85.0	804,000
"	"	90.0	397,000
"	"	95.0	197,000
3.0	"	25.0	35,390,000
"	"	27.5	25,340,000
"	"	30.0	4,497,000
"	"	35.0	1,966,000
"	"	37.5	417,000
"	"	45.0	300,000
"	"	55.0	108,000

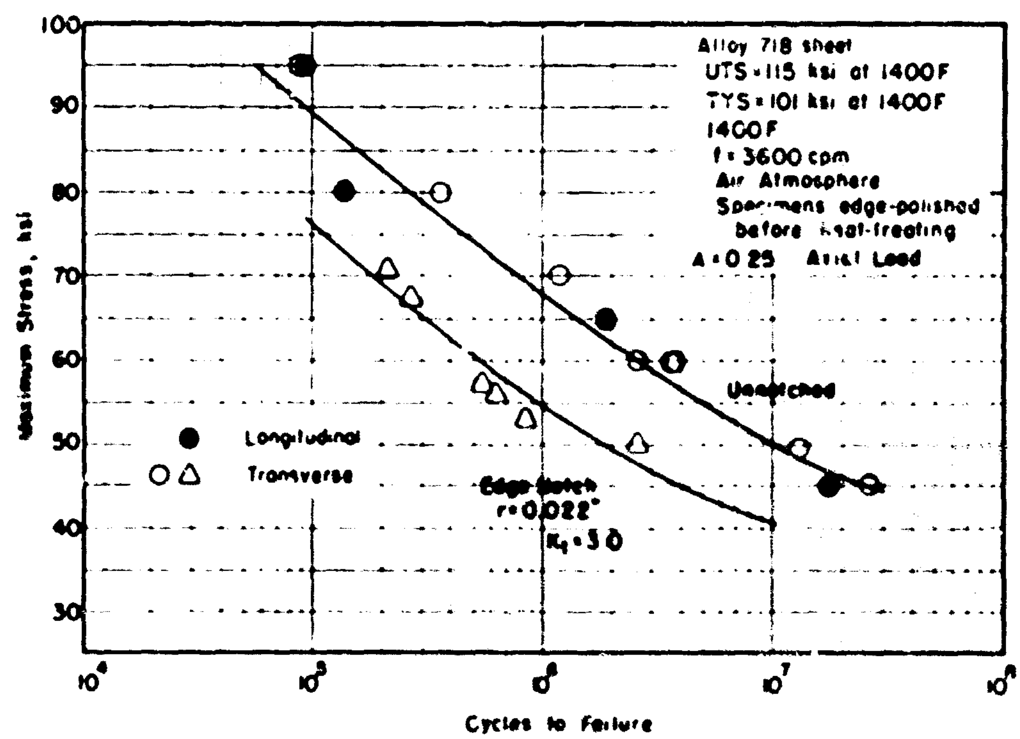


S-N DIAGRAM FOR ALLOY 718 SHEET AT 1400 F WITH STRESS RATIO, A = 0.67 (unnotched and edge-notched)

Fatigue data for Alloy 718 sheet at 1400 F and stress ratio, A = 0.25 and heat treated as per AMS 5596A.

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Cycles to Failure
1.0	T	45.0	26,500,000
"	"	50.0	13,630,000
"	"	60.0	2,502,000
"	"	60.0	3,789,000
"	"	60.0	3,843,000
"	"	70.0	1,216,000
"	"	80.0	378,000
"	"	95.0	88,000
"	L	45.0	18,700,000
"	"	65.0	1,959,000
"	"	80.0	130,000
"	"	95.0	91,000
3.0	T	50.0	2,537,000
"	"	53.5	838,000
"	"	56.0	618,000
"	"	57.5	529,000
"	"	67.5	283,000
"	"	70.0	216,000

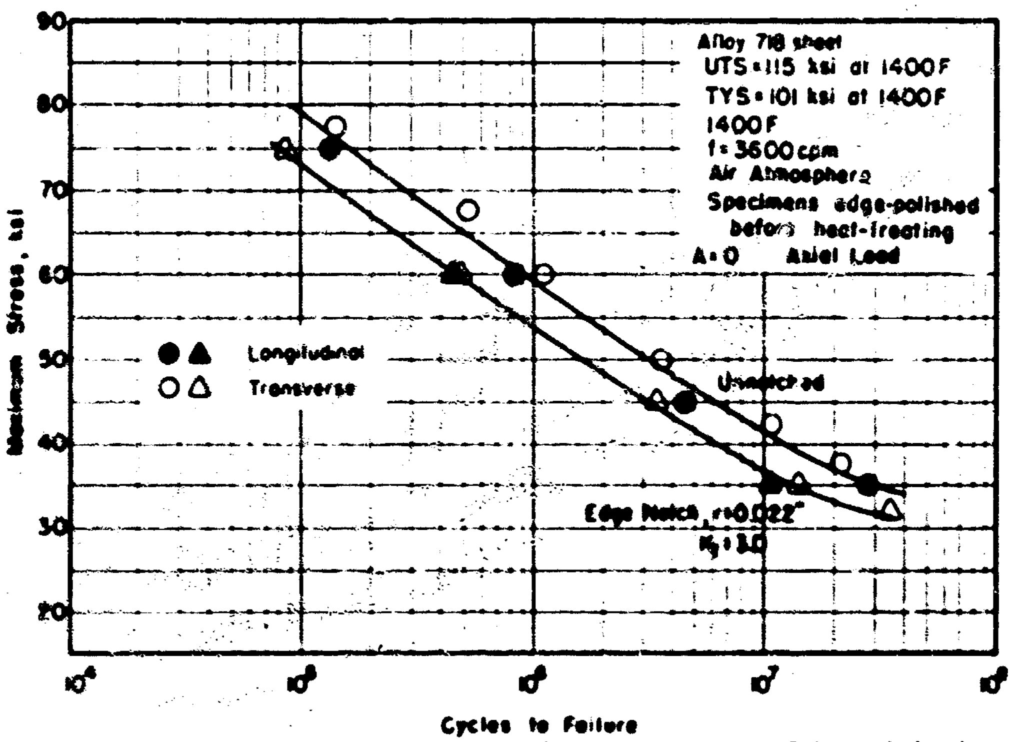


S-N DIAGRAM FOR ALLOY 718 SHEET AT 1400 F WITH STRESS RATIO, A = 0.25 (unnotched and edge-notched).

Fatigue data for Alloy 718 sheet at 1400 F and stress ratio A = 0 (stress rupture) and heat treated as per AMS 5596A

Ref: 65927

Stress Concentration, K_t	Test Direction	Maximum Stress (ksi)	Time to Rupture: Hours	Time to Rupture: Equivalent Cycles
1.0	T	37.5	100.3	21,464,000
"	"	42.5	48.4	10,454,000
"	"	50.0	16.9	3,650,000
"	"	60.0	5.4	1,166,000
"	"	67.5	2.4	518,000
"	"	77.5	0.6	130,000
"	L	35.0	135.3	29,224,000
"	"	45.0	21.1	4,557,000
"	"	60.0	3.8	820,000
"	"	75.0	0.6	129,000
3.0	T	32.0	160.7	34,711,000
"	"	35.0	66.7	14,407,000
"	"	45.0	15.3	3,304,000
"	"	60.0	2.3	496,000
"	"	75.0	0.4	86,000
"	L	35.0	49.2	10,627,000
"	"	60.0	2.0	432,000



S-N DIAGRAM FOR ALLOY 718 SHEET AT 1400 F WITH STRESS RATIO, A = 0 (unnotched and edge-notched).

DMIC

data sheet

Base Material: Nickel

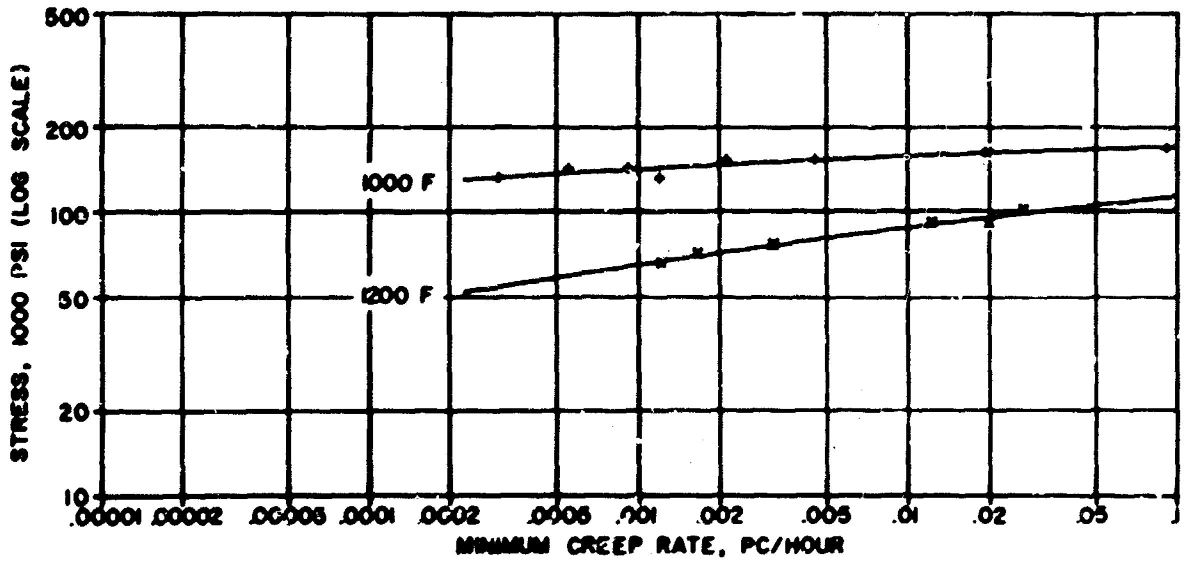
Metal or Alloy: Alloy 718

Form: Sheet

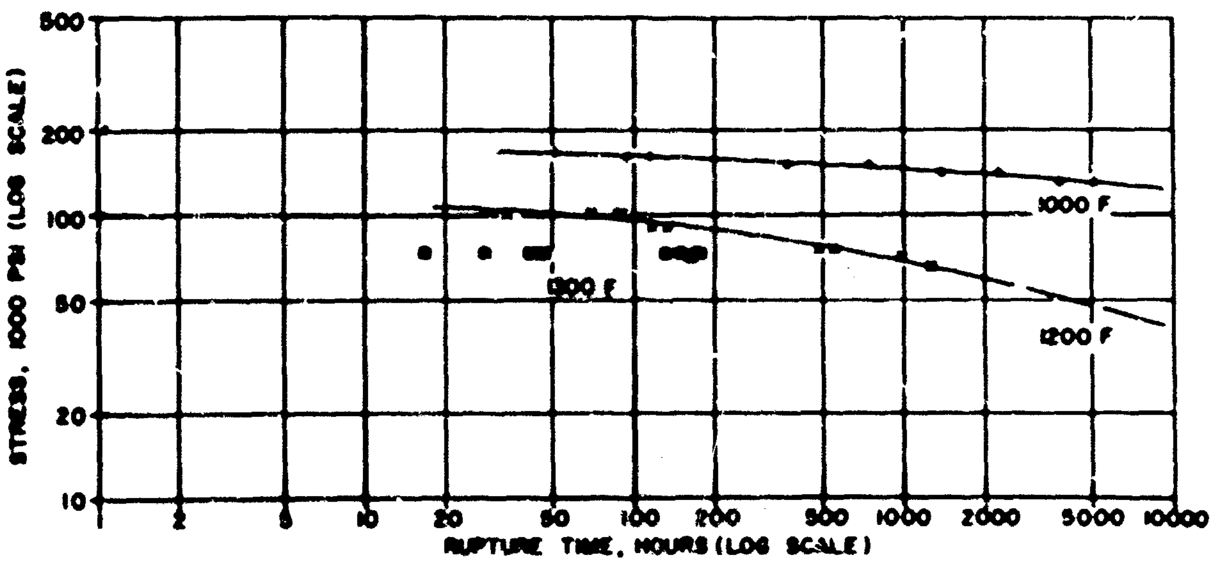
Condition: Aged

Alloy Data: Creep and rupture properties

Alloy 718 Sheet
Annealed at 1750 F and Aged



Stress-Creep Rate



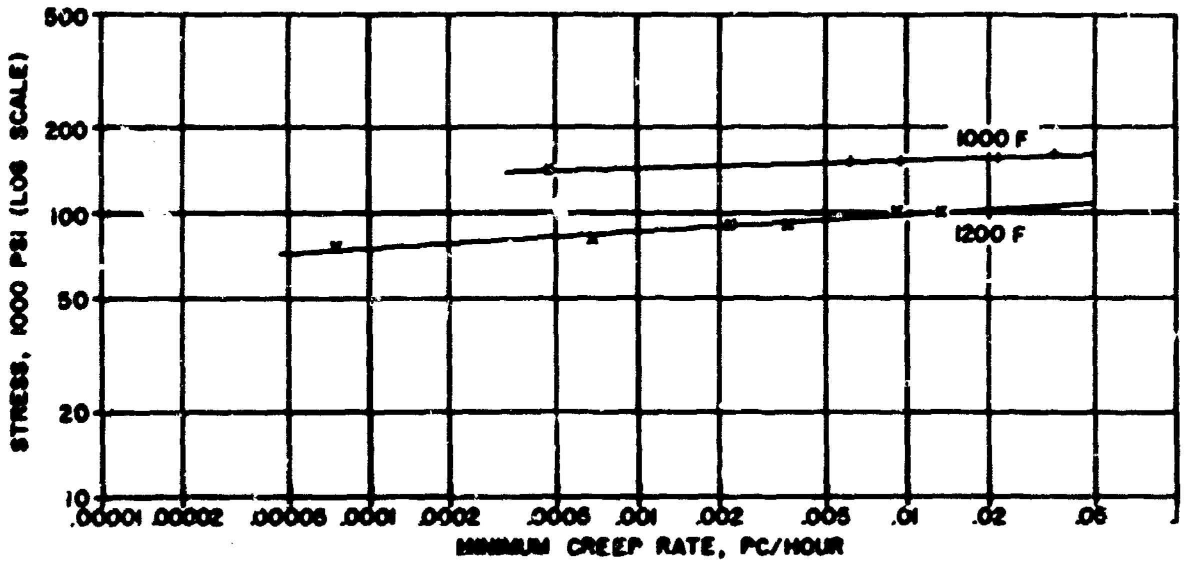
Stress-Rupture Time

From Data On p IV-39

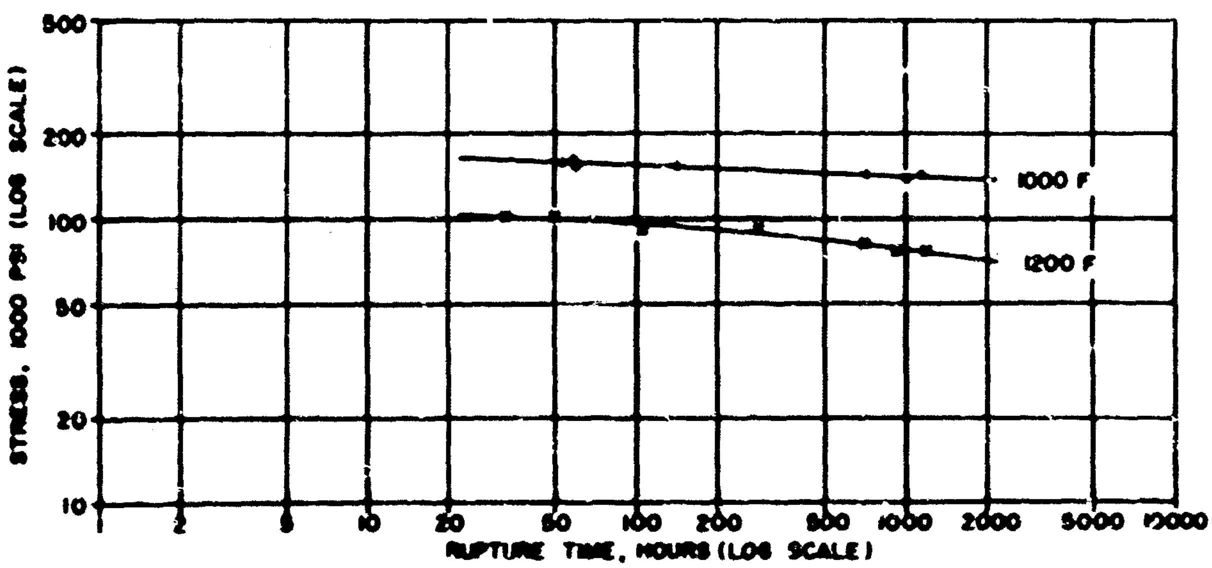
DMIC **data sheet**

Base Material: Nickel
Metal or Alloy: Alloy 718
Form: Sheet
Condition: Aged
Alloy Data: Creep and rupture properties

Alloy 718 Sheet and Plate
Annealed at 1950 F and Aged



Stress-Creep Rate



Stress-Rupture Time

From Data On p IV-40

ACCESSION NUMBER 67602
LOT NUMBER 29

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1100	125.0	240.00			4.4		
1100	125.0	240.00			4.0		
1100	120.0	170.0		.570			
1100	120.0	196.0		.700			
1100	120.0	250.0		1.3			
1100	120.0	290.0		1.0			
1200	100.0	84.50			9.5		
1200	100.0	80.30			11.4		
1200	90.0	60.0		.900			
1200	90.0	75.5		.800			
1200	90.0	80.0		1.0			
1200	90.0	100.5		1.0			
1300	72.5	45.70			26.4		
1300	72.5	41.20			25.0		
1300	50.0	73.0		.400			
1300	50.0	104.0		.500			
1300	50.0	105.5		1.0			
1300	50.0	102.0		1.0			

ACCESSION NUMBER 67609
LOT NUMBER 39

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	39.00			4.4		

ACCESSION NUMBER 67609
LOT NUMBER 40

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	43.00			4.0		

ACCESSION NUMBER 67609
LOT NUMBER 41

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	29.30			[illegible]		

ACCESSION NUMBER 67609
LOT NUMBER 42

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	16.30			4.4		

ACCESSION NUMBER 67614
LOT NUMBER 02

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	124.00			6.6		44

ACCESSION NUMBER 67614
LOT NUMBER 03

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	149.00			13.0		44

ACCESSION NUMBER 67614
LOT NUMBER 04

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	173.00			11.0		44
1300	72.5	164.00			6.0		44

ACCESSION NUMBER 67614
LOT NUMBER 06

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	70.0	150.90			6.3		45

[illegible]

[illegible]

DMIC data sheet

Base Material: Nickel — IV-40

Metal or Alloy: Alloy 718

Form: Sheet

Condition: Aged

Prop Data: Creep and rupture properties

ACCESSION NUMBER 61323
LOT NUMBER 2

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
800	175.0		.000000				
800	175.0	5102.0	.000040				
800	170.0	4402.0					
800	170.0	3204.0					
800	160.0	1000.0					
800	165.0	1000.0					
800	160.0	1006.0					
1000	165.0	56.20	.002000		10.5		
1000	160.0	92.70	.019400		6.0		
1000	160.0	113.00	.020200		6.0		
1000	150.0	733.00	.002100		4.0		
1000	150.0	366.00	.004900		3.0		
1000	140.0	1372.00	.000005		4.0		
1000	142.5	2226.00	.000047		4.3		
1000	130.0	3754.00	.000300		3.3		
1000	130.0	9006.10	.001100		2.0		
1200	104.0	33.00			6.0		
1200	105.0	66.00	.027003		11.0		
1200	95.0	132.00	.020000		12.0		
1200	90.0	118.00	.012290		9.3		
1200	75.0	844.00	.003150		9.0		
1200	75.9	470.04	.003150		8.3		
1200	70.0	973.00	.001600		6.0		
1200	62.0	1254.00	.001204		7.3		

CREEP AND RUPTURE STRENGTH

TEMP F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 PSI: 100 HOURS	1000 HOURS	10000 HOURS	STRESS FOR DESIGNATED CREEP RATE, 1000 PSI: 0.00001 PC/HOUR	0.0001 PC/HOUR	0.001 PC/HOUR
1000	166.0	144.4	122.5*	102.1*	121.5*	130.4
1200	92.7	60.1	42.7*	30.2*	48.1*	64.2*

*EXTRAPOLATED

ACCESSION NUMBER 61323
LOT NUMBER 3

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
800	170.5	-0.00			7.5		
800	165.0	4343.0	.000025				
800	160.0	-0.00			10.0		
800	170.0	1000.0	.000030				
800	160.0	4343.0	.000030				
1000	160.0	57.70	.036000		5.0		
1000	170.0	82.00	.021000		4.3		
1000	150.0	140.00	.006100		3.0		
1000	150.0	96.00	.004900		3.0		
1000	140.0	711.00	.000444		1.5		
1000	140.0	1142.00	.000400		2.0		
1000	135.0	603.0					
1000	135.0	1000.00			2.0		
1200	100.5	46.00	.013000		3.0		
1200	103.0	32.20	.009200		1.6		
1200	90.0	800.00	.002200		1.0		
1200	90.0	104.00	.003900		8.0		
1200	80.0	697.00	.000400		1.5		
1200	86.0	144.0	.000200				
1200	75.0	913.00			1.0		
1200	75.0	1103.00	.000070		1.0		

CREEP AND RUPTURE STRENGTH

TEMP F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 PSI: 100 HOURS	1000 HOURS	10000 HOURS	STRESS FOR DESIGNATED CREEP RATE, 1000 PSI: 0.00001 PC/HOUR	0.0001 PC/HOUR	0.001 PC/HOUR
1000	151.5	138.0	125.0*	125.2*	123.7*	142.7
1200	94.2	76.0	54.1*	64.2*	74.7	86.5

*EXTRAPOLATED

Condition: Cold rolled 20% then heat treated as follows:

Lot	Heat Treatment
2	Solution treated at 1750 F, then aged 1325 F/8 hr + 1150 F 10 hr
3	Solution treated at 1950 F, then aged 1350 F/8 hr + 1150 F/12 hr

Ref 61323

DMIC

data sheet

Base Material: Nickel   EV-41

Metal or Alloy: Alloy 718

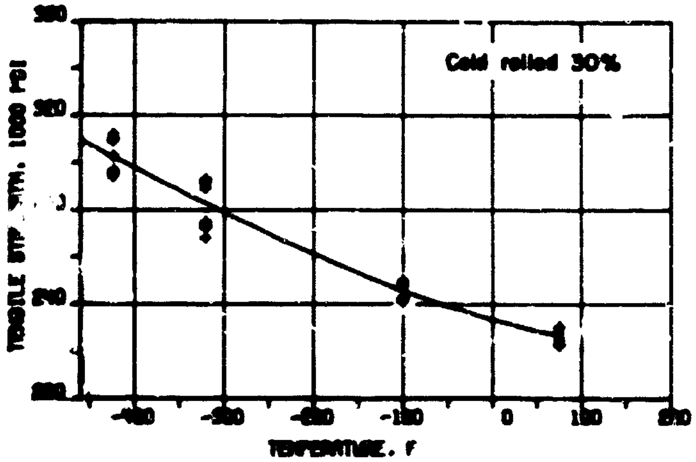
Form: Sheet

Condition: Cold rolled and aged

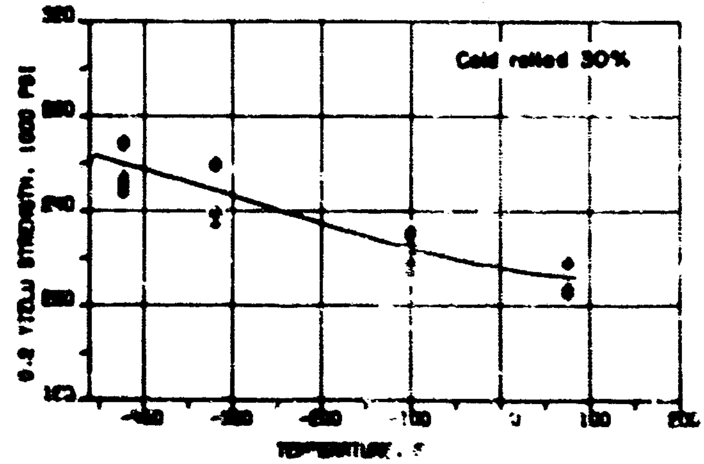
Alloy Data: Tensile properties

Alloy 718 Sheet

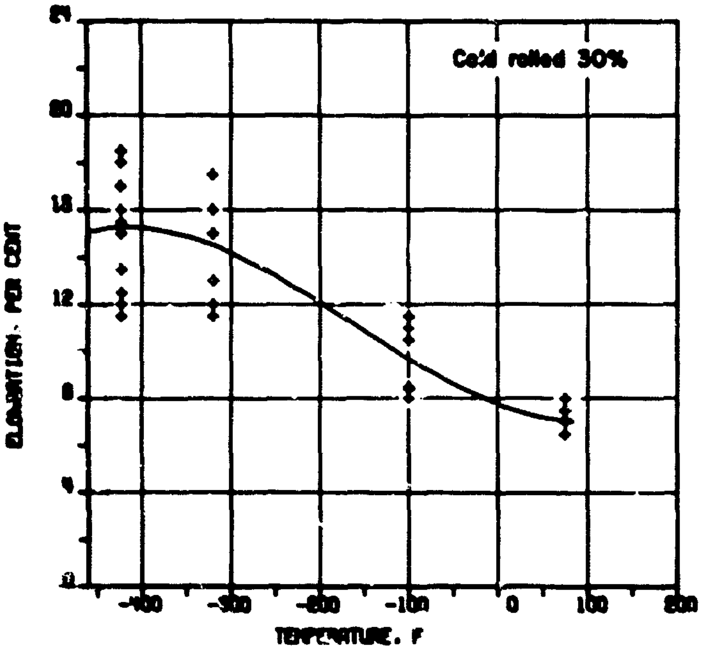
Cold Rolled and Aged



Tensile Strength



.2% Yield Strength


Cold rolled 30%
ELONGATION, PER CENT
TEMPERATURE, F
24
20
16
12
8
4
0
-400
-300
-200
-100
0
100
200

Elongation

ACCESSION NUMBER 61323
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
80		207.0	210.0	9.5		L
80		203.5	217.0	7.5		T
800		174.0	185.0	9.5		L
800		178.0	190.0	9.5		T
1000		170.0	183.3	12.0		L
1000		173.0	184.6	7.0		T
1200		145.0	174.5	10.0		L
1200		150.0	173.5	8.5		T

Condition: Cold rolled 26%, then aged 1325 F/8 hr + 1150 F/19 hr without intermediate anneal.

ACCESSION NUMBER 65177
LOT NUMBER 6

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		97.3	[illegible]	40.0		L
-423		91.0	170.0	40.0		T
-320		70.0	152.0	52.0		L
-320		75.0	147.0	43.0		T
75		67.3	115.3	43.0		L
75		67.0	116.0	49.0		T

ACCESSION NUMBER 65177
LOT NUMBER 7

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		200.0	267.0	21.0		L
-423		195.0	262.0	21.0		T
-320		186.0	263.0	20.0		L
-320		187.0	239.0	22.4		T
75		158.0	192.9	21.0		L
75		154.0	189.0	20.0		T

ACCESSION NUMBER 65177
LOT NUMBER 8

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		209.0	270.0	20.0		L
-423		204.0	278.0	27.0		T
-320		189.0	252.0	33.0		L
-320		198.0	267.0	20.0		T
[illegible]		171.0	216.0	23.0		L
[illegible]		170.0	213.0	23.0		T
[illegible]		197.0	195.0	20.0		L
75		197.0	[illegible]	20.0		T

ACCESSION NUMBER 65177
LOT NUMBER 9

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-422		239.0	286.0	20.0		L
-423		228.0	281.0	22.0		T
-320		227.0	240.0	25.0		L
-320		214.0	284.0	21.0		T
75		197.0	216.0	15.0		L
75		183.0	204.0	13.0		T

ACCESSION NUMBER 65177
LOT NUMBER 11

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		269.0	309.0	15.0		L
-423		251.0	295.0	16.0		T
-320		259.0	292.0	16.0		L
-320		236.0	273.0	13.0		T
-100		230.0	249.0	11.0		L
-100		210.0	242.0	8.6		T
75		218.0	230.0	7.1		L
75		200.0	223.0	7.0		T

ACCESSION NUMBER 65177
LOT NUMBER 13

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		287.0	337.0	12.0		L
-320		274.3	297.0	9.2		L
75		231.3	240.0	5.8		L

ACCESSION NUMBER 65177
LOT NUMBER 14

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		288.5	329.0	13.0		L
-320		263.0	284.0	12.0		L
-100		248.0	263.0	8.0		L
75		226.0	242.3	8.3		L

ACCESSION NUMBER 65177
LOT NUMBER 15

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		309.6	333.0	8.3		L
-320		280.0	310.0	3.3		L
-100		265.0	283.0	3.8		L
75		248.0	257.0	3.3		L

DMIC

data sheet

Base Material: Nickel

Metal or Alloy: Alloy 718

Form: Sheet

Condition: Cold-rolled and Aged

Alloy Data: Tensile properties

ACCESSION NUMBER 65177
LOT NUMBER 16

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		342.0	356.0	3.5		L
-320		333.0	340.0	.7		L
75		270.0	281.0	2.0		L

Lot	Condition
6	Annealed 1800 F/1 hr
7,8	Annealed 1800 F/1 hr, then aged 1325/8 hr + 1150 F/10 hr
9	Cold rolled 20%, then aged 1325 F/8 hr + 1150 F/10 hr*
11	Cold rolled 30%, then aged 1325 F/8 hr + 1150 F/10 hr*
13,14	Cold rolled 50%, then aged 1325 F/8 hr + 1150 F/10 hr*
15	Cold rolled 50%, then aged 1250 F/8 hr + 1150 F/10 hr*
16	Cold rolled 70%, then aged 1250 F/8 hr + 1150 F/10 hr*

* 1h intermediate anneal prior to aging

Ref: 65177

DMIC data sheet

Base Material: Nickel IV-48

Metal or Alloy: Alloy 718

Form: Sheet

Condition: [illegible]

Alloy Data: [illegible]

ACCESSION NUMBER 61323
LOT NUMBER 1

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
75	20.6	219.5				
75	20.0	204.5				
800	20.0			175.0		
800	20.0			165.0		
800	20.0			155.0	1383.0	
800	26.0			150.0	2964.0	
800	20.2	170.2		180.0		
800	20.0	186.5		175.0		
800	20.0	181.2		165.0	1718.0	
1000	2.3			160.0	47.0	
1000	2.3			150.0	154.6	
1000	2.3			140.0	34.8	
1000	2.3			130.0	454.8	
1000	6.0			135.0	94.0	
1000	6.0			120.0	233.6	
1000	6.0			119.0	86.2	
1000	6.0			100.0	331.4	
1000	6.0			90.0	903.1	
1000	20.0	160.5		150.0	2.0	
1000	20.0	170.5		150.0	12.5	
1000	20.0			130.0	28.4	
1000	20.0			110.0	73.8	
1000	20.0			90.0	226.0	
1000	20.0			80.0	227.8	
1000	20.0			70.0	633.4	
1000	20.5			50.0	1787.0	
1000	20.0			130.0	7.4	
1000	20.0			110.0	9.9	
1000	20.0			90.0	25.8	
1000	20.0			70.0	71.3	
1000	20.0			50.0	220.8	
1000	20.0			40.0	513.8	
1000	20.0			35.0	2064.0	
1200	2.3			70.0	67.4	
1200	2.3			60.0	190.2	
1200	2.3			50.0	363.0	
1200	6.0			50.0	87.7	
1200	6.0			45.0	295.0	
1200	6.0			40.0	464.4	

ACCESSION NUMBER 61323
LOT NUMBER 1

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
1200	6.0			36.0	1401.0	
1200	20.0	134.5		75.0	1.3	
1200	20.0	141.0		55.0	10.3	
1200	20.0			40.0	40.1	
1200	20.0			30.0	2364.0	
1200	20.0			30.0	3591.0	
1200	20.0			25.0	5510.0	
1200	20.0			75.0	8.3	
1200	20.0			55.0	8.6	
1200	20.0			40.0	6.3	
1200	20.0			35.0	5.1	
1200	20.0			25.0	1052.0	

Condition: Cold rolled 26%, then aged 1325 F/8 hr + 1150 F/10 hr without intermediate anneal.

Ref: 61323

ACCESSION NUMBER 65177
LOT NUMBER 6

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	146.0				
-423	6.3	142.0				
-320	6.3	121.0				
-320	6.3	114.0				
75	6.3	89.2				
75	6.3	88.0				

ACCESSION NUMBER 65177
LOT NUMBER 7

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	254.0				
-423	6.3	259.0				
-320	6.3	234.0				
-320	6.3	220.6				
75	6.3	198.0				
75	6.3	196.0				

ACCESSION NUMBER 65177
LOT NUMBER 8

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	276.0				
-423	6.3	269.0				
-320	6.3	214.0				
-320	6.3	229.0				
-100	6.3	221.0				
-100	6.3	223.0				
75	6.3	207.0				
75	6.3	206.0				

ACCESSION NUMBER 65177
LOT NUMBER 9

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	293.0				
-423	6.3	294.0				
-320	6.3	272.0				
-320	6.3	262.0				
75	6.3	230.0				
75	6.3	226.0				

ACCESSION NUMBER 65177
LOT NUMBER 11

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	309.0				
-423	6.3	301.0				
-320	6.3	292.0				
-320	6.3	285.0				
-100	6.3	267.0				
-100	6.3	262.0				
75	6.3	240.0				
75	6.3	240.0				

ACCESSION NUMBER 65177
LOT NUMBER 13

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	320.0				
-320	6.3	304.0				
75	6.3	261.0				

ACCESSION NUMBER 65177
LOT NUMBER 14

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	293.0				
-320	6.3	260.0				
-100	6.3	239.0				
75	6.3	230.0				

ACCESSION NUMBER 65177
LOT NUMBER 15

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	304.0				
-320	6.3	275.0				
-100	6.3	204.0				
75	6.3	260.0				

ACCESSION NUMBER 65177
LOT NUMBER 16

NOTCHED TENSILE AND RUPTURE DATA

TEMP. F	STRESS INTENSITY FACTOR K	TENSILE: NOTCHED STRENGTH 1000 PSI	TENSILE: RED. IN AREA PER CENT	RUPTURE: STRESS 1000 PSI	RUPTURE: DURATION HOURS	RUPTURE: RED. IN AREA PER CENT
-423	6.3	260.0				
-320	6.3	290.0				
75	6.3	193.0				

Lot	Condition
6	Annealed 1800 F/1 hr
7,8	Annealed 1800 F/1 hr, then aged 1325/8 hr + 1150 F/10 hr
9	Cold rolled 20%, then aged, 1325 F/8 hr + 1150 F/10 hr
11	Cold rolled 30%, then aged, 1325 F/8 hr + 1150 F/10 hr
13,1	Cold rolled 50%, then aged, 1325 F/8 hr + 1150 F/10 hr
15	Cold rolled 50%, then aged, 1250 F/8 hr + 1150 F/10 hr
16	Cold rolled 70%, then aged, 1250 F/8 hr + 1150 F/10 hr

* No intermediate anneal prior to aging

Ref 65177

DMIC data sheet

Metal or Alloy: Alloy 718

Form:

Condition:

Fatigue data for Alloy 718 (cold rolled + aged) sheet at room temperature and stress ratio A=0.33 (unnotched, K_t= 1)

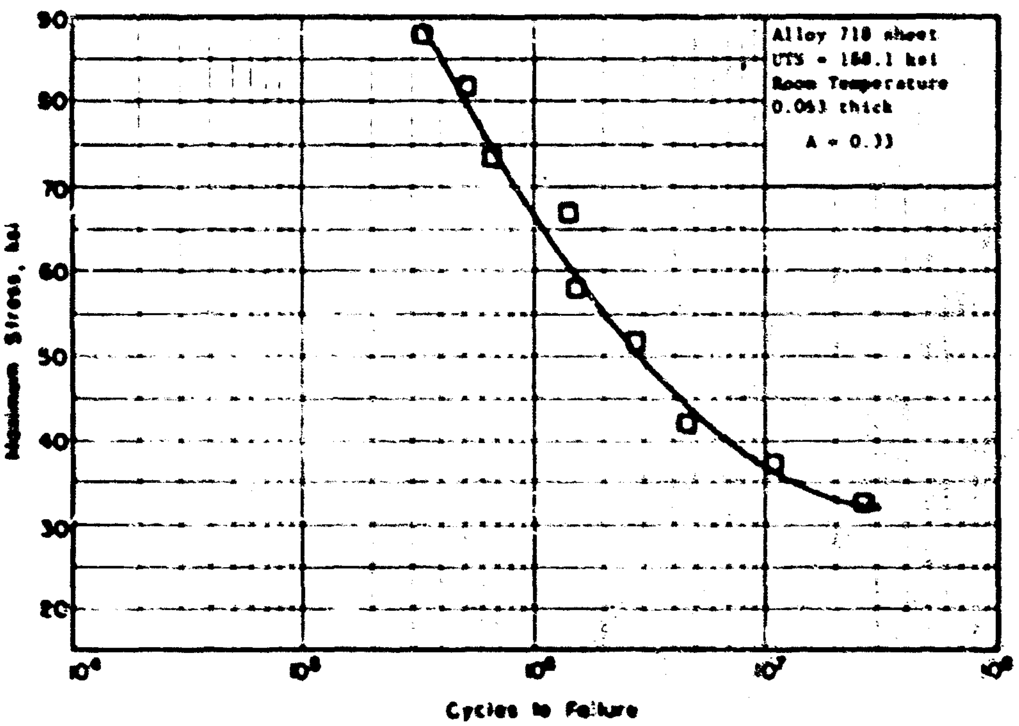
Condition: Solution treated at 1600 F, then cold rolled 15%, then aged at 1325 F/16 hr.

Thickness: 0.063 inch

UTS: 188.1 ksi

Ref: 61646

Maximum Stress (ksi)	Cycles to Failure
123.7	126,000
138.5	66,000
166.2	34,000
153.3	51,000
10[illegible].1	157,000
[illegible]2.3	274,000
184.7	12,000
73.9	437,000
6[illegible].6	1,026,000
55.4	2,632,000



[illegible] ALLOY 718 (COLD ROLLED + AGED) SHEET AT ROOM TEMPERATURE WITH STRESS RATIO, A = 0.33 (unnotched, K_t= 1)

Base Material: Nickel IV-48

Metal or Alloy: Alloy 718

data sheet

Form: Sheet

Condition: Cold rolled and aged

Alloy Data: Creep and rupture properties

ACCESSION NUMBER 61323

LOT NUMBER 1

ORIGINAL CREEP AND RUPTURE DATA

TEMP., F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
800	100.0	1100.0	.000040				
800	105.0	1300.0	.000040				
800	104.0	1000.0	.000018				
800	100.0	1300.0	.000017				
1000	175.0	42.2R	.030000		3.0		
1000	175.0	34.5R	.057000		4.0		
1000	170.0	61.6R	.016400		2.3		
1000	170.0	73.6R	.017000		2.0		
1000	160.0	207.0R	.002100		1.0		
1000	160.0	80.4R	.004000		1.0		
1000	150.0	220.9R	.000300		3.0		
1000	150.0	144.0R	.001600		1.5		
1000	135.0	1077.0R	.000044		2.0		
1000	135.0	430.0	.000160				
1000	125.0	922.0	.000033				
1200	150.0	.7R			3.0		
1200	150.0	.6R			2.5		
1200	100.0	15.5R			1.5		
1200	100.0	10.3R			1.0		
1200	75.0	46.2R	.002200		1.3		
1200	75.0	40.2R	.001900		1.5		
1200	60.0	173.0R	.000950		1.3		
1200	60.0	193.0R	.000200		1.0		
1200	50.0	679.C	.000225				
1200	50.0	530.0R	.000330		.5		
1200	40.0	2499.0R	.000120		1.3		
1200	40.0	1899.0R	.000107		1.0		

CREEP AND RUPTURE STRENGTH

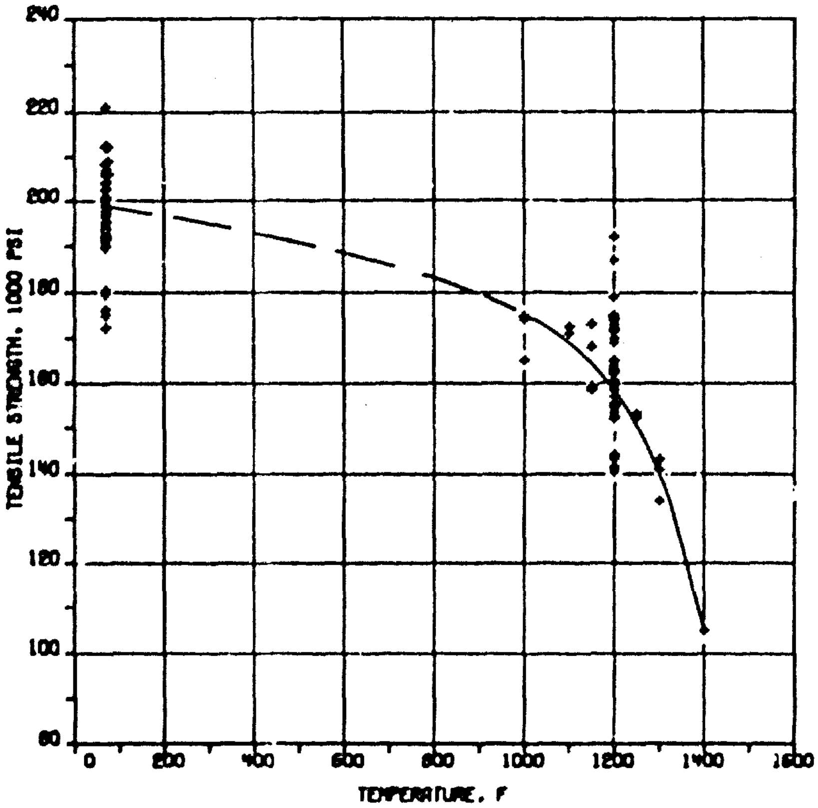
TEMP F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 PSI			STRESS FOR DESIGNATED CREEP RATE, 1000 PSI		
	100 HOURS	1000 HOURS	10000 HOURS	0.00001 PC/HOUR	0.0001 PC/HOUR	0.001 PC/HOUR
800				176.9*	191.8*	205.7*
1000	142.3	130.0	119.0*	110.2*	135.9	152.0
1200	66.6	44.9	29.7*	16.3*	38.9*	67.3

*EXTRAPOLATED

Condition: Cold rolled 20%, then aged 1325 F/8 hr + 1150 F/10 hr without intermediate anneal.

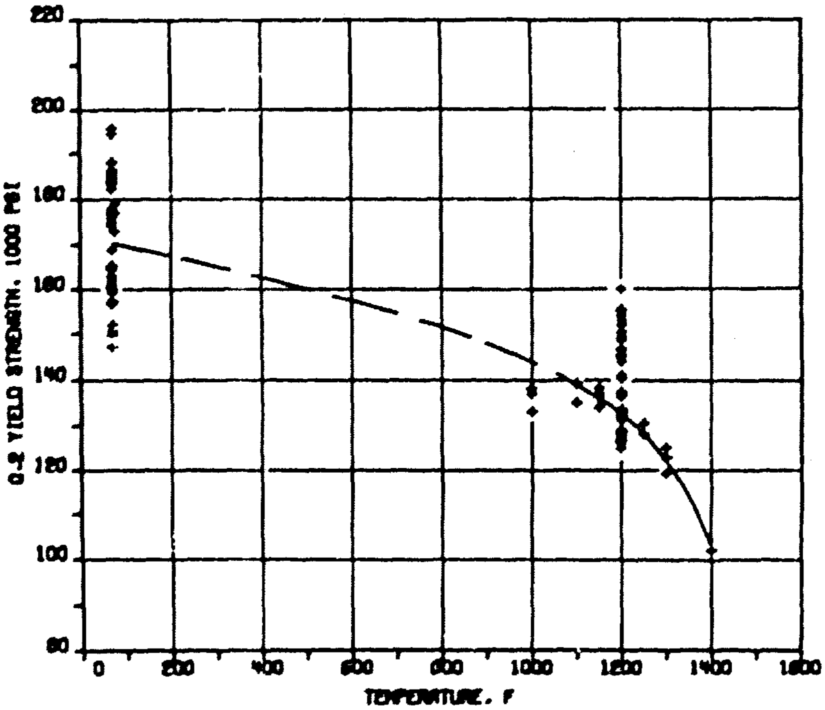
Ref: 61323

Alloy 718 Bars, Forgings, and Billet
Annealed at 1750 F and Aged



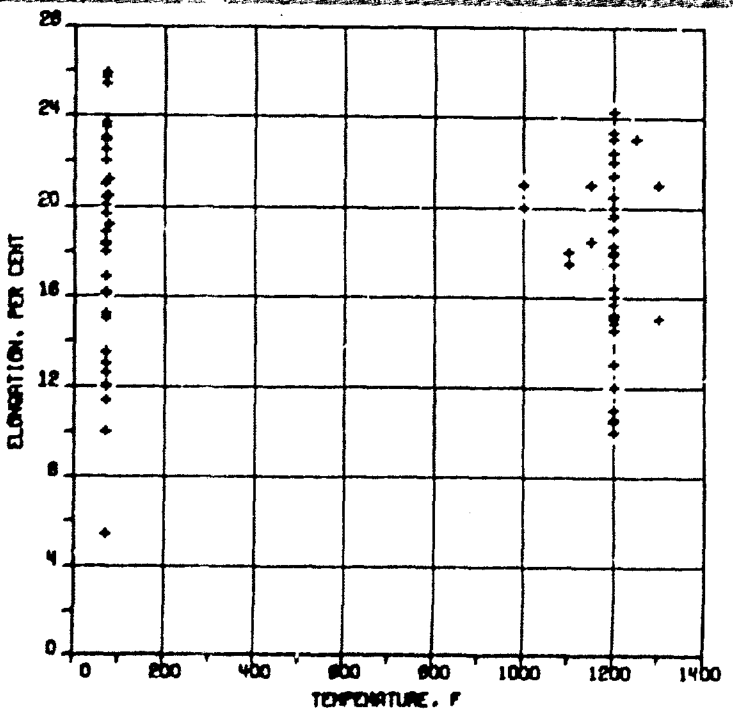
Tensile Strength

See Page IV-58 for Heat Treatment Conditions

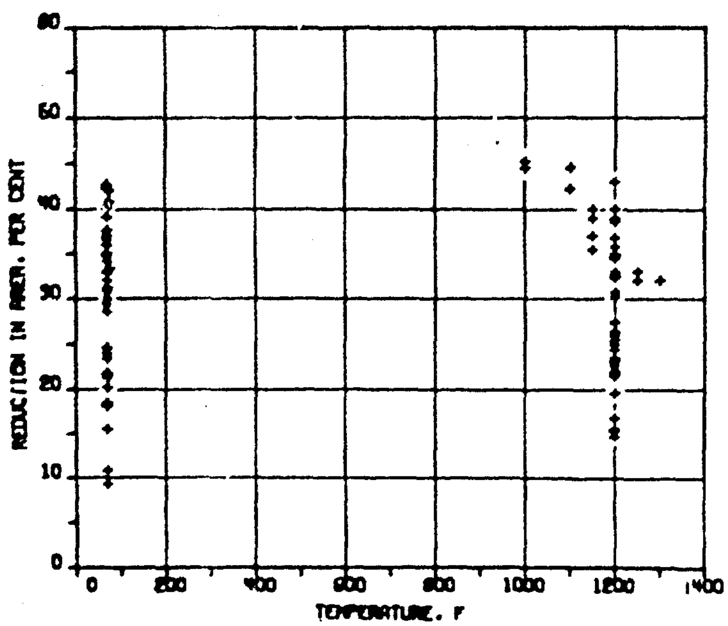


.2% Yield Strength

See Page IV-58 for Heat Treatment Conditions



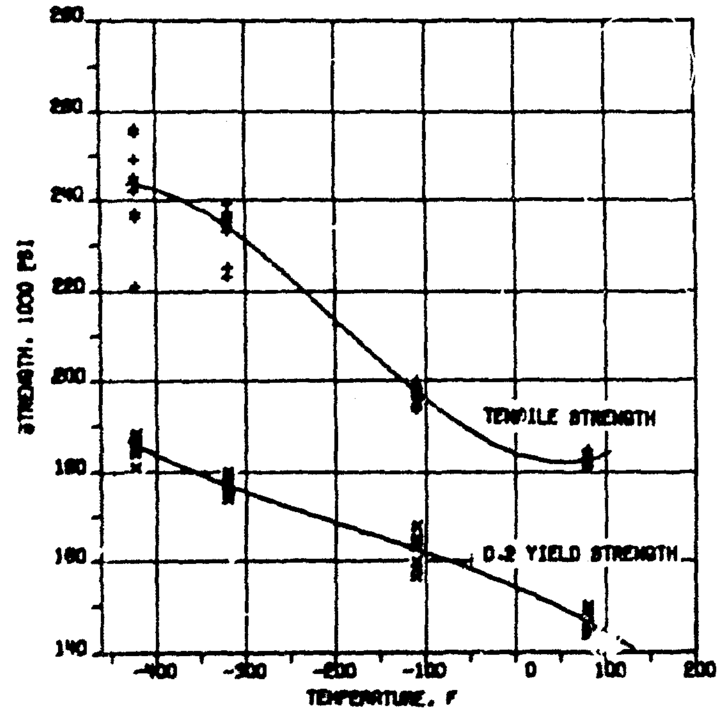
Elongation

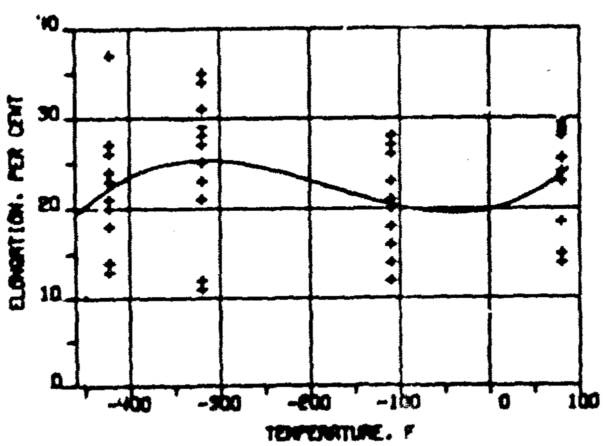


Reduction in Area

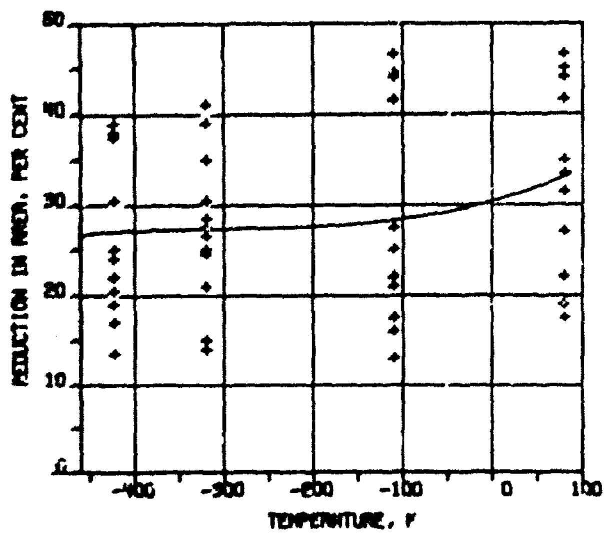
See Page IV-58 for Heat Treatment Conditions

Alloy 718 Forgings
Annealed at 1950 F and Aged





Elongation



Reduction in Area

See Page IV-58 for Heat Treatment Conditions

ACCESSION NUMBER 50031
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
75		183.0	213.0	18.0		
600		170.0	194.0	20.0		
1000		165.0	188.0	20.5		
1200		155.0	181.0	22.5		
1300		136.0	152.0	24.0		
1400		103.0	105.0	30.5		
1500		73.0	75.0	44.5		L

ACCESSION NUMBER 63742
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
80		140.5	169.5	8.0	13.1	L
80		138.3	174.2	12.0	16.0	L
80		133.6	170.9	14.0	18.2	L
80		126.6	155.4	4.0	10.1	L
80		126.2	154.4	5.0	8.9	L
80		135.0	171.3	14.0	16.8	L
80		140.7	150.5	2.0	8.8	L
80		141.7	159.0	3.0	10.9	L
80		143.2	179.9	17.0	17.3	L
80		144.8	177.2	18.5	18.7	L
80		147.4	174.6	10.5	18.9	L
80		149.8	166.0	12.0	20.7	L
80		130.5	153.8	4.0	5.0	L
80		129.7	154.8	4.0	4.0	L
80		131.5	162.7	6.0	9.2	L

ACCESSION NUMBER 63742
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
80		132.2	159.1	4.0	10.9	L
80		146.4	172.7	5.0	7.3	L
80		148.8	185.8	14.0	16.8	L
80		129.5	171.3	16.5	21.5	L
80		143.0	171.1	4.0	9.3	L
80		144.6	169.7	6.0	12.0	L
80		136.6	163.2	6.8	11.3	L
80		142.8	175.8	11.0	16.1	L
80		132.6	152.7	2.9	5.0	L
80		133.4	156.4	3.0	6.7	L
80		130.9	153.6	4.0	6.6	L
80		133.0	157.8	4.8	7.8	L
80		134.4	156.4	3.5	8.9	L
80		132.6	150.7	3.0	5.8	L
80		137.9	174.6	18.0	21.1	L
80		146.8	186.2	24.0	28.7	L
80		139.3	179.5	20.0	23.9	L
80		142.3	182.1	29.0	36.0	L

ACCESSION NUMBER 63743
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
-423		181.1	245.0	26.0	37.5	L
-423		185.9	237.0	23.0	38.0	L
-423		187.9	235.0	24.0	38.0	L
-423		187.0	246.0	37.0	39.0	L
-423		186.5	255.0	27.0	24.6	T
-423		184.2	245.0	21.0	20.5	T
-423		185.0	249.0	23.0	25.0	T
-423			221.0	18.0	30.5	T
-423		185.8	244.8	20.0	22.0	S
-423		187.8	242.0	14.0	17.0	S
-423		185.4	249.0	20.0	19.6	S
-423		186.2	242.0	13.0	13.5	S
-320		174.0	236.0	27.0	30.5	L
-320		178.0	239.0	35.0	38.0	L
-320		175.0	237.0	24.0	39.0	L
-320		173.0	239.0	31.0	41.6	L
-320		179.8	236.0	25.0	24.5	T
-320		178.9	236.0	28.0	25.0	T
-320		177.2	235.0	29.0	28.5	T
-320		177.3	234.0	23.0	24.5	T
-320		178.1	223.0	12.0	15.0	S
-320		176.4	233.0	21.0	21.0	S
-320		177.0	225.0	11.0	14.0	S
-320		175.3	234.0	27.0	27.5	S
-110		164.0	198.2	28.0	44.0	L
-110		161.5	200.0	29.0	41.5	L
-110		164.0	198.9	28.0	46.5	L
-110		163.2	198.2	27.0	44.5	L
-110		167.8	199.0	20.0	21.6	T
-110		164.6	197.0	18.0	22.0	T
-110		163.2	196.5	23.0	25.0	T
-110		165.0	197.7	16.0	21.0	T
-110		158.0	195.4	17.0	16.0	S
-110		159.9	194.5	14.0	17.5	S
-110		157.8	200.0	21.0	27.5	S
-110		156.7	193.6	12.0	13.0	S
80		144.1	182.9	29.0	45.0	L
80		144.3	181.8	28.0	46.5	L
80		143.9	181.0	29.5	44.0	L
80		146.5	183.8	28.5	41.5	L
80		147.0	184.0	18.5	22.0	T
80		146.3	183.4	24.0	31.5	T
80		145.3	184.7	25.5	35.0	T
80		146.3	182.7	19.5	33.5	T
80		145.4	181.4	14.0	17.5	S
80		149.2	182.7	23.0	27.0	S
80		150.0	181.0	15.0	19.0	S
80		146.3	180.9	24.0	35.0	S

ACCESSION NUMBER 67595
LOT NUMBER 11

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		160.0	202.0	20.0	40.0	
800		140.0	165.0	20.0	42.0	
1200		134.0	144.0	20.0	40.0	
1300		125.0	140.0	20.0		
1400		105.0	110.0	25.0		

ACCESSION NUMBER 67595
LOT NUMBER 12

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		152.0	190.0			
1000		133.0	165.0			
1200		132.[illegible]	152.0			
1300		125.6	134.0			
1400		102.0	105.0			

ACCESSION NUMBER 67596
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		156.7	189.6	13.0	23.4	T
1200		132.3	155.5	12.9	16.0	T

ACCESSION NUMBER 67596
LOT NUMBER 2

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		186.5	208.6	15.[illegible]	24.6	
70		189.7	212.2	12.[illegible]	21.0	
70		176.8	206.3	12.4	18.5	
1200		133.7	155.3	12.0	15.6	T
1200		151.9	173.8	20.0	30.5	
1200		146.7	172.1	12.5	21.8	
1200		145.7	171.5	18.0	30.1	

ACCESSION NUMBER 67596
LOT NUMBER 3

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		183.7	207.2	20.4	40.1	
70		182.6	204.5	18.0	36.5	
70		184.2	209.5	16.9	31.2	
70		184.3	205.9	16.2	30.0	
1200		141.1	140.7	14.8	25.0	
1200		140.8	142.5	15.2	26.4	

ACCESSION NUMBER 67595
LOT NUMBER 4

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		170.7	194.0	16.0	28.1	T
70		170.3	192.8	17.0	29.3	T
70		172.0	195.6	19.0	31.2	T

ACCESSION NUMBER 67596
LOT NUMBER 5

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		175.1	192.4	15.0	24.0	T
70		176.3	195.6	12.0	21.0	T
70		175.4	193.2	12.0	23.0	T
70		175.1	190.2	12.0	26.5	T

ACCESSION NUMBER 67596
LOT NUMBER 6

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		169.3	189.2	15.0	20.2	T
70		172.3	192.8	18.0	27.3	T
70		171.7	193.9	18.0	28.1	T
70		170.5	192.0	18.0	30.4	T

ACCESSION NUMBER 67596
LOT NUMBER [illegible]

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		174.5	202.0	19.3	32.2	
70		173.9	193.6	15.0	26.9	

ACCESSION NUMBER 67496
LOT NUMBER 8

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		147.3	172.3	14.0	18.5	T
70		157.3	179.6	10.0	21.6	T
70		149.9	175.8	12.0	21.3	T
70		156.8	180.4	12.0	20.2	T
70		150.9	176.3	1[illegible].0	18.5	T
1200		126.7	141.4	[illegible]1.0	19.6	T
1200		131.3	144.3	13.9	23.1	T
1200		126.2	141.7	10.0	25.5	T
1200		120.7	140.4	12.0	26.4	T
1200		127.3	143.5	13.3	23.1	T

ACCESSION NUMBER 67596
LOT NUMBER 9

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		168.7	194.4	12.0	[illegible]	T
70		167.7	185.2	13.0	2[illegible].4	T
70		169.[illegible]	188.4	13.0	26.4	T
70		169.5	1[illegible]9.1	13.[illegible]	23.5	T
70		171.3	189.2	15.0	25.7	T
70		170.7	196.8	17.6	28.1	T
70		172.3	190.4	12.8	81.0	T
70		170.2	187.6	13.0	26.1	T
70		169.3	188.4	13.0	29.3	T

DMIC

ACCESSION NUMBER 67602
LOT NUMBER 20

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	145.0	165.0	192.0	23.0	36.0	
70	137.0	159.3	191.0	23.0	37.0	
70	144.0	163.0	199.0	22.0	37.0	
70	135.0	160.3	192.5	23.0	36.0	
70	135.0	160.0	193.5	22.0	36.0	
70	141.0	162.0	194.0	22.0	36.0	
1150	118.0	136.5	158.5	21.0	40.0	
1150	120.0	137.0	159.2	21.0	39.0	
1200	105.0	128.0	157.0	18.6	38.0	
1200	105.0	133.0	150.5	18.0	35.0	
1200	111.0	132.1	159.4	22.0	39.0	
1200	107.0	133.5	140.0	23.0	46.0	
1250	104.5	128.0	152.2	23.0	33.0	
1250	112.2	130.5	153.2	23.0	32.0	
1300	99.5	119.3	141.0	15.0	32.0	
1300	107.3	122.8	143.3	21.0	32.0	

ACCESSION NUMBER 67602
LOT NUMBER 21

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70		163.0	200.0	22.5	42.3	
70		164.5	202.5	22.0	42.3	
1000		138.2	174.8	20.0	45.2	
1000		137.0	174.0	21.0	44.5	
1100		135.0	171.0	19.0	44.5	
1100		139.2	172.5	17.5	42.2	
1150		134.0	168.0	19.5	35.5	
1150		130.2	173.0	18.5	37.0	
1200		133.5	165.0	19.0	21.5	
1200		132.5	163.9	16.0	22.0	

ACCESSION NUMBER 67614
LOT NUMBER 78

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	145.0	163.0	201.0	21.0	37.6	L
1200	116.5	133.0	164.0	22.4	34.7	L

ACCESSION NUMBER 67614
LOT NUMBER 79

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	142.0	176.0	195.4	19.4	30.0	L
1200	112.0	136.5	164.0	17.9	30.1	L

ACCESSION NUMBER 67614
LOT NUMBER 80

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	139.5	197.5	195.0	25.7	42.7	L
70	136.0	161.7	200.0	23.6	26.6	L
70	141.0	160.5	200.5	25.6	26.9	L
1200	115.2	129.6	155.0	17.4	23.9	L

ACCESSION NUMBER 67614
LOT NUMBER 81

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	129.0	156.8	191.5	25.9	34.1	L
1200	119.0	137.0	157.0	24.7	26.0	L
1200	108.0	125.0	154.5	18.3	27.4	L

ACCESSION NUMBER 67614
LOT NUMBER 82

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	147.0	195.6	204.0	18.9	40.5	L
1200	132.0	148.7	172.0	15.1	34.5	L

ACCESSION NUMBER 67614
LOT NUMBER 83

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	149.0	175.0	208.5	20.1	35.0	L
1200	120.0	145.5	171.5	23.3	32.5	L

ACCESSION NUMBER 67614
LOT NUMBER 84

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	154.0	194.5	207.0	13.5	33.0	L
1200	137.3	155.0	162.0	15.0	25.0	L

ACCESSION NUMBER 67614
LOT NUMBER 85

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	141.0	176.2	192.5	19.7	28.6	L
1200	128.0	144.0	162.0	15.7	43.0	L

ACCESSION NUMBER 67614
LOT NUMBER 86

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	140.5	176.0	203.0	9.4	9.3	T
70	150.0	185.0	212.6	10.3	39.1	L
1200	145.5	160.0	187.0	10.5	14.7	T
1200	116.0	140.3	142.5	19.6	22.4	L

ACCESSION NUMBER 67614
LOT NUMBER 87

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	154.0	177.0	198.0	20.1	32.0	L

ACCESSION NUMBER 67614
LOT NUMBER 88

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	147.5	183.5	221.0	16.?	34.7	L
1200	125.0	145.0	179.0	21.4	36.8	L

ACCESSION NUMBER 67614
LOT NUMBER 89

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	148.3	178.0	212.5	16.1	35.1	L
1200	131.9	149.5	174.5	20.5	32.9	L

ACCESSION NUMBER 67614
LOT NUMBER 90

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	139.4	168.9	208.6	23.7	29.4	L
1200	106.8	128.3	149.0	19.7	23.5	L

ACCESSION NUMBER 67614
LOT NUMBER 91

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	157.5	180.0	208.5	22.9	32.8	L
1200	145.5	155.5	192.0	22.4	30.7	L

ACCESSION NUMBER 67614
LOT NUMBER 96

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	153.0	177.5	197.2	11.4	15.5	T
70	146.5	165.5	192.5	10.0	10.4	T
70	144.5	164.5	194.5	15.7	18.1	T
1200	143.5	150.5	192.5	10.6	19.6	T
1200	126.5	137.5	162.5	14.8	15.3	T
1200	124.5	131.2	193.5	20.5	24.6	T

ACCESSION NUMBER 67614
LOT NUMBER 100

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	139.5	169.5	198.0	25.6	23.9	L
70	145.8	172.0	197.9	25.7	23.0	L
70	140.0	170.0	196.0	26.6	26.1	L

ACCESSION NUMBER 67614
LOT NUMBER 101

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	136.5	163.5	188.5	7.6	9.3	T

ACCESSION NUMBER 67614
LOT NUMBER 102

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	129.5	160.5	194.0	27.5	30.0	L
70	129.3	163.0	201.0	25.4	26.0	L
70	137.5	165.5	196.0	16.9	23.2	T
70	138.5	167.0	195.5	16.0	24.0	T

ACCESSION NUMBER 67614
LOT NUMBER 103

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	123.2	149.5	191.5	9.8	9.5	T
70	118.5	149.0	187.0	8.2	11.8	T
70	135.5	166.0	195.0	27.1	32.7	L

ACCESSION NUMBER 67614
LOT NUMBER 104

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	149.0	175.0	197.5	12.7	4.9	L
70	149.5	174.5	166.5	8.2	11.6	L

ACCESSION NUMBER 67614
LOT NUMBER 105

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	143.5	[illegible]	169.2	14.3	23.9	T
70	128.0	[illegible]	196.5	16.9	22.6	T
70	126.0	169.0	196.0	12.4	46.8	L
70	137.5	171.0	191.5	13.3	10.4	T
70	138.8	172.5	197.0	26.1	44.6	L
70	147.8	173.0	198.2	26.4	42.2	T

DMIC

data sheet

Base Metal: Nickel [illegible]

Metal or Alloy: Alloy 718

Form: Bars, Forgings, and Billets

Condition: Aged

Alloy Data: Tensile properties

ACCESSION NUMBER 67614
LOT NUMBER 106

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	120.0	145.3	180.5	19.5	25.4	T
70	122.5	144.0	177.3	20.0	21.0	T
70	139.1	171.5	196.5	13.6	17.0	T
70	140.4	170.5	194.0	16.8	20.4	T

ACCESSION NUMBER 67614
LOT NUMBER 107

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	141.5	174.5	198.0	12.9	10.9	T
70	141.5	174.5	198.0	12.9	13.2	T
70	119.0	171.5	198.0	19.1	16.8	T
70	131.5	171.0	198.0	14.2	18.5	T
70	130.0	169.5	200.5	18.1	23.4	T
70	145.5	177.8	200.0	7.9	10.1	T
70	137.0	180.0	197.5	6.1	8.2	T

ACCESSION NUMBER 67614
LOT NUMBER 108

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	138.5	163.5	185.5	23.6	32.5	T
70	136.5	160.5	183.5	18.4	33.8	T
70	131.5	161.5	184.0	16.6	28.0	T
70	136.5	163.5	184.0	15.0	24.6	T
70	143.0	174.0	192.5	7.8	13.0	T
70	144.0	175.5	197.0	12.2	15.1	T
70	144.5	177.5	197.5	13.7	16.7	T
70	135.5	175.5	195.0	14.8	16.6	T

ACCESSION NUMBER 67614
LOT NUMBER 109

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	143.5	168.5	189.5	13.0	13.0	T

ACCESSION NUMBER 67614
LOT NUMBER 110

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	146.5	173.5	198.5	16.8	21.0	T
70	147.0	174.0	197.3	18.8	21.3	T
70	146.5	170.5	193.5	11.2	14.5	T
70	147.0	172.5	195.5	14.1	17.0	T
70	148.0	176.0	198.0	16.1	16.4	T

ACCESSION NUMBER 67614
LOT NUMBER 113

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
70	134.4	160.0	188.5	23.0	40.0	L

ACCESSION NUMBER 67657
LOT NUMBER 9

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
77	155.0	173.0	206.0	20.5	42.0	L
1200	134.0	152.0	170.0	16.4	32.3	L

ACCESSION NUMBER 67657
LOT NUMBER 10

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
77	155.0	179.0	212.0	21.2	40.8	L
1200	135.0	153.0	174.0	17.5	35.8	L

ACCESSION NUMBER 67657
LOT NUMBER 11

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST DIR
77	151.0	177.0	209.0	19.7	33.3	L
1200	134.0	154.0	175.0	15.7	34.9	L

Tensile properties at cryogenic, room, and elevated temperatures for Alloy 718 bars, forgings, and billets.

Reference	Lot No.	Heat Treatment
50031	1	"Aged"
63742	1	8 hr/1325 F, 8 hr/1150 F
63743	1	45 min/1950 F, 10 hr/1400 F, 10 hr/1200 F
67595	11	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67595	12	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67596	1	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67596	2	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67596	3	1 hr/1800 F, 8 hr/1325 F, 8 hr/1150 F
67596	4	1 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67596	5	1 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67596	6	1 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67596	7	1 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67596	8	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67596	9	1 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67602	20	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67602	21	1 hr/1750 F, 8 hr/1325 F
67614	78	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	79	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	80	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	81	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	82	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	83	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	84	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	85	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	86	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	87	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	88	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	89	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	90	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	91	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	99	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	100	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	101	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	102	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	103	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	104	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	105	2 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	106	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	107	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	108	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	109	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	110	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	111	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	112	2 hr/1950 F, 10 hr/1400 F, 10 hr/1200 F
67614	113	1 hr/1800 F, 8 hr/1325 F, 18 hr/1150 F
67657	9	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67657	10	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67657	11	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F

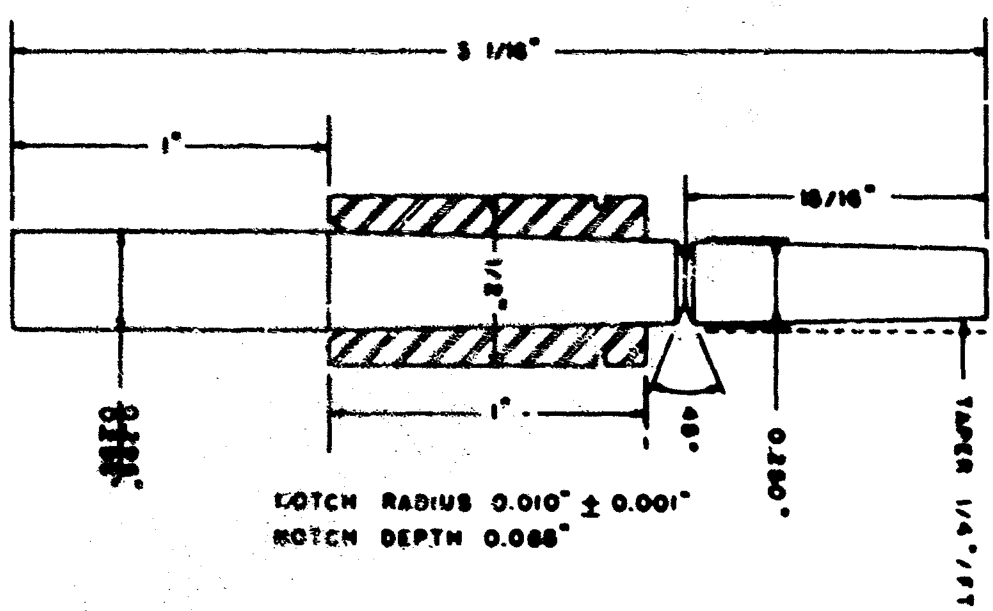
DMIC

Impact properties of Alloy 718 at cryogenic temperatures. Both mill annealed and heat treated specimens were tested. Specimens were machined to the dimensions shown in figures from standard No. 5 taper pins. The substandard size was necessary due to the 30 ft-lb capacity of the testing machine.

Heat treatment utilized was: aged at 1325 F for 7 hours, furnace cooled at 20 F per hour to 1150 F, and air cooled out of furnace.

Test Temperature K	Impact Energy in ft-lbs. Alloy 718 Annealed	Alloy 718 Heat Treated
300	8.3	1.0
300	8.1	1.0
300	7.6	1.0
300	8.4	1.1
300	7.0	1.0
	avg. 7.9	avg. 1.0
194	8.1	1.0
194	8.8	1.2
194	7.4	1.0
194	7.0	0.9
194	8.7	1.0
	avg. 8.0	avg. 1.0
77	8.2	0.9
77	7.3	0.8
77	7.0	0.7
77	7.8	0.7
	6.8	0.8
	avg. 7.4	avg. 0.78
20	7.9	0.7
20	7.8	0.7
20	7.6	0.8
20	7.3	0.8
20	8.3	0.8
	avg. 7.8	avg. 0.76

Ref: DMIC 62082



Unnotched (K_t = 1.0) rotating bending fatigue data at room temperature for solution treated and aged Alloy 718 bar, R = -1 (A = ∞) heat treated as follows:

Solution treated 1750 F(1 hr.) A.C.
Aged 1325 F(8 hr.) F.C.
Aged 1150 F(10 hr.) A.C.

Ref: A

Low Cycles*		High Cycles**		
Stress (ksi)	Cycles	Stress (ksi)	Cycles	Remarks
		100.0	121,000	Failed
		94.0	293,000	Failed
		85.0	10,163,000	Ran out
		90.0	1,193,000	Failed
		87.5	2,804,000	Failed
		86.0	10,023,000	Failed
		87.0	11,071,000	Ran out
		105.0	69,000	Failed
100.0	12,000	85.0	3,320,000	Failed
100.0	6,000	85.0	950,000	Failed
90.0	45,000	85.0	1,467,000	Failed
90.0	11,250	85.0	10,048,000	Ran out
90.0	25,174	85.0	3,354,000	Failed
100.0	1,500	85.0	4,632,000	Failed
100.0	1,500	85.0	948 000	Failed
100.0	750	82.0	10,027,000	Ran out
110.0	286	82.0	2,978,000	Failed
105.0	437	82.0	11,071,000	Ran out
110.0	144	82.0	27,081,000	Ran out
105.0	815	82.0	24,514,000	Ran out
95.0	3,250	82.0	10,022,000	Ran out
95.0	65,000	82.0	3,983,000	Failed
105.0	815	82.0	1,274,000	Failed
88.0	50,000	82.0	936,000	Failed

* Tested at 100 cpm at indicated stress level to indicated number of cycles followed by conventional high cycle testing to 10^7 cycles or failure.

** Tested at 10,000 cpm, Heat No. 5391

DMIC

data sheet

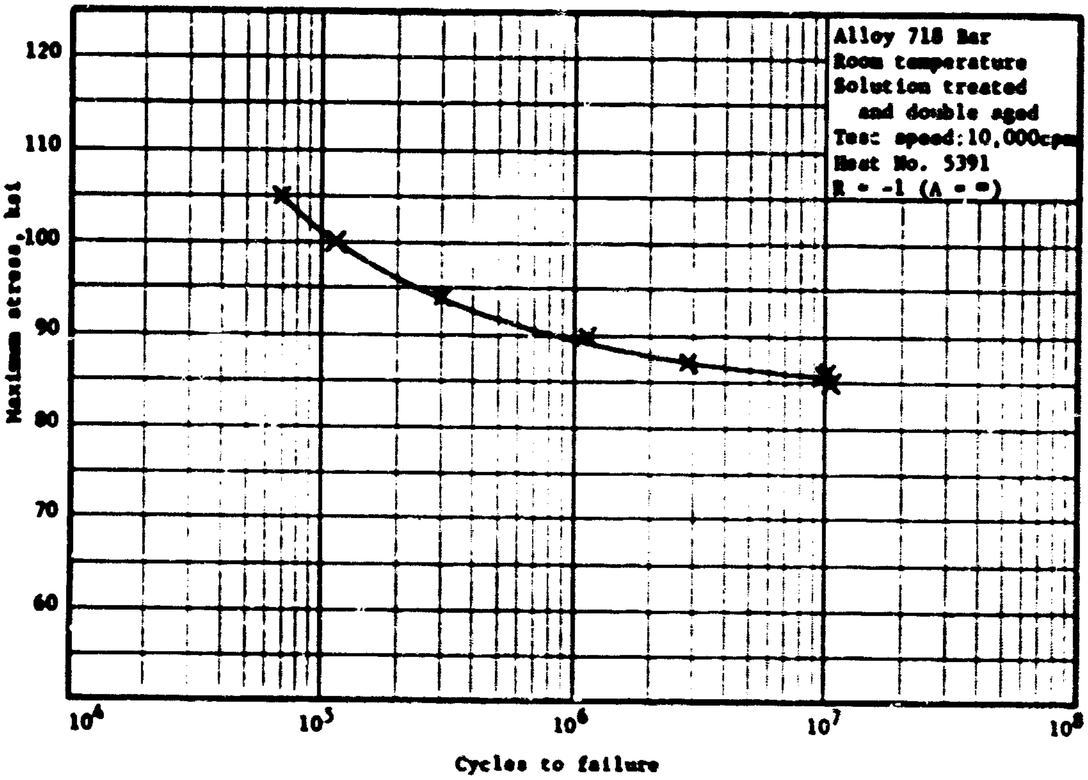
Base Material: Nickel [illegible]

Metal or Alloy: Alloy 718

Form: Bar

Condition: Fatigue properties [illegible]

Alloy Data:



Unnotched (K_t = 1.0) rotating bending fatigue behavior (S-N) of solution treated and double aged Alloy 718 bar at room temperature. R = -1 (A = ∞)

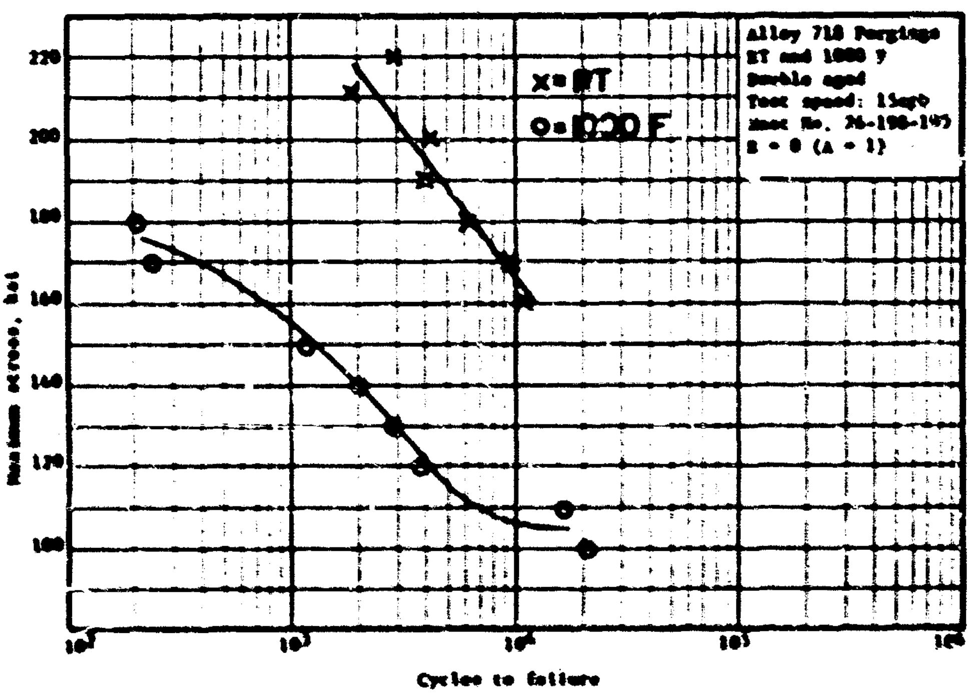
Ref: A

Unnotched (K_t = 1.0) pull-pull fatigue data at room temperature and 1000 F for double aged Alloy 718 "mini-[illegible]" forgings, R = 0 (A = 1) heat treated as follows:

Aged 1325 F(8 hr.) F.C.
Aged 1150 F(10 hr.) A.C.
Ref: A

Test temperature, F	Maximum stress, (ksi)	Cycles to failure
RT	170.0	9,272
	200.0	4,155
	160.0	12,863
	180.0	6,152
	211.5	1,994
	190.0	4,019
	220.0	2,968
1000	200.0	3
	180.0	220
	170.0	250
	150.0	1,326
	130.0	2,967
	100.0	22,179
	110.0	17,642
	120.0	3,952
	140.0	2,139

Heat No. 26-198-199
Test speed: 15 cph



Unnotched (K_t = 1.0) pull-pull low cycle fatigue behavior (S-N) of double aged Alloy 718 forgings at room temperature and 1000 F R = 0 (A = 1)

Ref: A

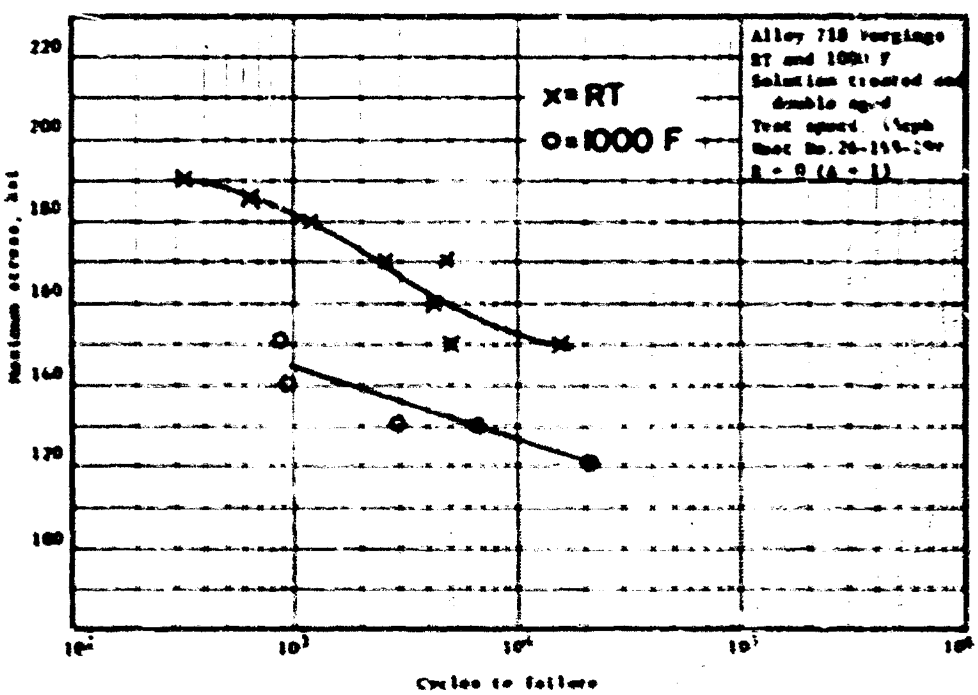
Unnotched (K_t = 1.0) pull-pull fatigue data at room temperature and 1000 F for solution treated and double aged Alloy 718 forgings, R = 0 (A = 1) heat treated as follows:

Solution treated	1750 F (1 hr.) A.C.
Aged	1325 F (8 hr.) F.C.
Aged	1150 F (10 hr.) A.C.

Ref: A

Test temperature, F	Maximum stress, (ksi)	Cycles to failure
RT	150.0	4,984
	160.0	4,268
	170.0	4,842
	180.0	1,398
	190.0	336
	160.0	16,675
	170.0	2,695
	185.0	627
1000	150.0	875
	140.0	961
	130.0	3,000
	120.0	20,810
	160.0	1*
	140.0	6,699
	130.0	6,700

* Failed on loading
Heat No. 26-198-199
Test speed: 15 cph



Unnotched (K_t = 1.0) pull-pull low cycle fatigue behavior (S-N) of solution treated and double aged alloy 718 forgings at room temperature and 1000 F
R = 0 (A = 1)

DMIC **data sheet**

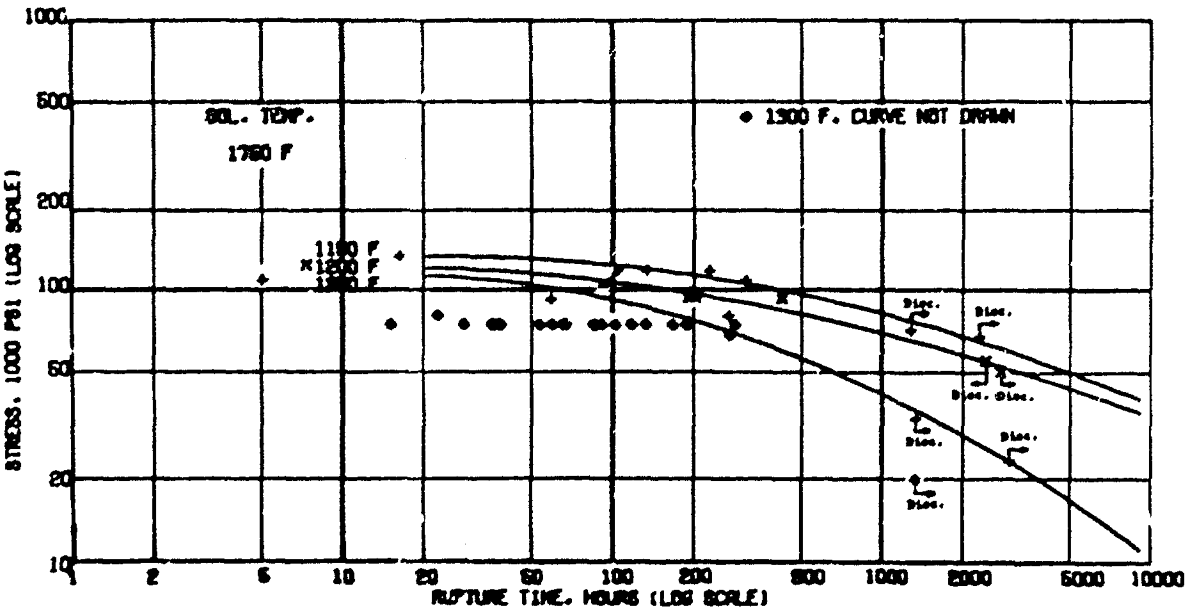
Base Material: Nickel

Metal or Alloy: Alloy 718

Form: Bars, forgings, and billets

Condition: Aged

Alloy Data: Creep and rupture properties

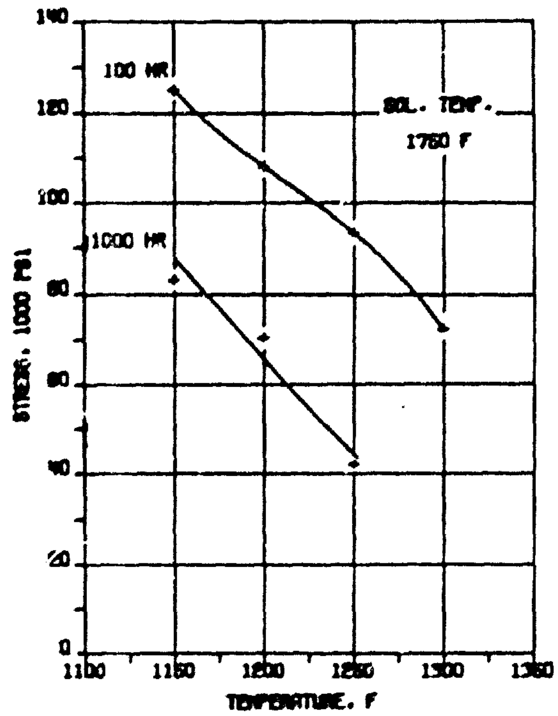


Stress-Rupture Time

See Heat Treatment Conditions on Page IV-68

DMIC data sheet

Alloy 718 Bars, Forgings, and Billet
Annealed at 1750 F and Aged



Rupture Strength

See Heat Treatment Conditions on Page IV-68

DMIC data sheet

Base Metals: Nickel

Name & Alloy: Alloy 718

Form: Bars, forgings, and billets

Condition: Aged

Alloy data: Creep and rupture properties

ACCESSION NUMBER 67044
LOT NUMBER 9

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	103.0R			8.6		429
1300	75.0	60.2R			11.4		429
1300	75.0	92.0R			12.0		429

ACCESSION NUMBER 67594
LOT NUMBER 3

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	194.2R			11.4		429
1300	75.0	284.0R			8.3		426

ACCESSION NUMBER 67602
LOT NUMBER 20

CREEP AND RUPTURE STRENGTH

TEMP F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 PSI: 100 HOURS	1000 HOURS	10000 HOURS	STRESS FOR DESIGNATED CREEP RATE, 1000 PSI: 0.00001 PC/HOUR	0.0001 PC/HOUR	0.001 PC/HOUR
1150	123.0	82.5	53.2*			
1200	111.0	71.0	33.0*			
1250	93.3	41.9	10.3*			
1300	80.3	26.7	2.2*			

*EXTRAPOLATED

ACCESSION NUMBER 67602
LOT NUMBER 20

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1150	135.0	16.4R			4.2		
1150	119.0	105.9R			4.C		
1150	114.0	231.3R			7.0		
1150	110.0	137.0R			7.6		
1150	72.0	890.0		.109			
1150	72.0	1700.0D					
1150	60.0	1000.0		.100			
1150	60.0	2320.0D					
1200	125.0	7.4R			5.3		
1200	100.0	93.4R			3.0		
1200	84.0	420.4R			4.4		
1200	56.0	2492.0		.120			
1200	56.0	2463.1D					
1200	51.0	2586.0		.114			
1200	51.0	2887.1D					
1250	115.0	9.1R			9.2		
1250	91.3	59.7R			3.4		
1250	61.3	355.7R			2.4		
1250	34.7	1050.0		.100			
1250	30.0	1330.0D					
1250	23.5	7474.0		.132			
1250	23.5	2999.0D					
1300	91.4	22.7R			5.8		
1300	75.0	90.9R			4.8		
1300	75.0	86.7R			6.6		
1300	75.0	19.3R			7.4		
1300	60.0	97.4R			2.3		
1300	24.0	961.0		.139			
1300	[illegible]	1161.1D					

ACCESSION NUMBER 67602
LOT NUMBER 21

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1000	132.5	.3		.100			
1050	125.0	8.5		.100			
1100	125.0	163.6R			2.0		
1100	125.0	200.0R			6.4		
1100	120.0	16.0		.100			
1100	110.0	155.0		.100			
1100	10.0	220.0		.900			
1150	110.0	10.0		.100			
1150	110.0	313.0R			7.1		
1150	95.0	210.0		.100			
1150	19.0	115.3		.900			
1150	19.0	170.0		1.000			
1200	95.0	192.0R			7.1		
1200	95.0	285.1R			5.7		
1200	90.0	141.0		.100			
1200	85.0	195.0		.100			

ACCESSION NUMBER 67614
LOT NUMBER 7A

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	100.0	70.6					43

ACCESSION NUMBER 67614
LOT NUMBER 7B

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1200	100.0	150.3					39

ACCESSION NUMBER 67614
LOT NUMBER 8A

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	100.0	96.1					42

ACCESSION NUMBER 67614
LOT NUMBER 81

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURA-TION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	101.0	76.2					41

DMIC data sheet

ACCESSION NUMBER 67614
LOT NUMBER 82

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	54.1R			11.2	24.6	43

ACCESSION NUMBER 67614
LOT NUMBER 83

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	118.3R			8.0	20.5	44

ACCESSION NUMBER 67614
LOT NUMBER 84

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	133.0R			10.5	24.3	43

ACCESSION NUMBER 67614
LOT NUMBER 85

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	160.7R			17.0	10.1	43

ACCESSION NUMBER 67614
LOT NUMBER 88

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	30.8R			37.0	53.7	45

ACCESSION NUMBER 67614
LOT NUMBER 89

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	28.4R			15.0	59.2	43

ACCESSION NUMBER 67614
LOT NUMBER 90

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	67.6R			11.2	22.3	44

ACCESSION NUMBER 67614
LOT NUMBER 91

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	87.2R			19.5	22.7	43

ACCESSION NUMBER 67614
LOT NUMBER 99

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	.9R					40
1300	75.0	108.5R			7.4	14.2	41

ACCESSION NUMBER 67614
LOT NUMBER 113

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	117.4					41

ACCESSION NUMBER 67657
LOT NUMBER 9

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	65.0R			10.0		

ACCESSION NUMBER 67657
LOT NUMBER 10

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	36.7R			15.1		

ACCESSION NUMBER 67657
LOT NUMBER 11

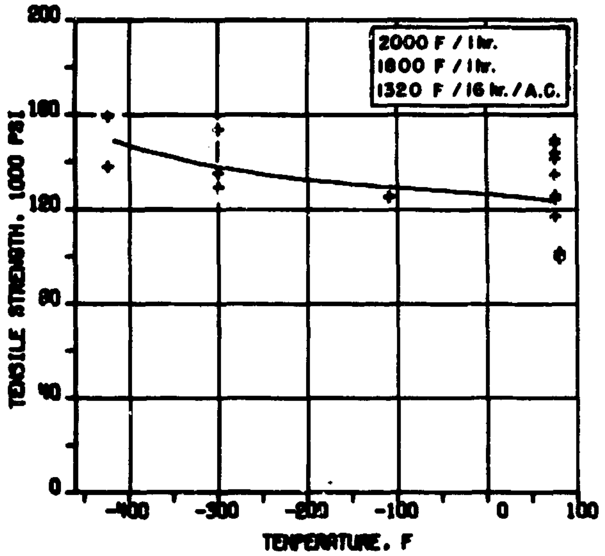
ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	75.0	36.6R			14.1		

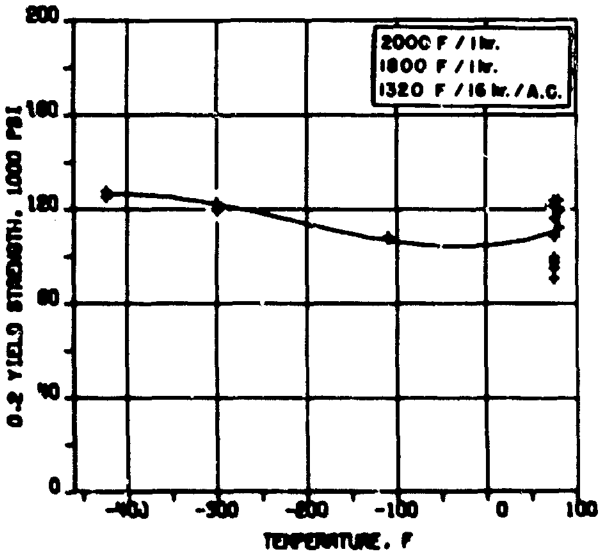
Creep and rupture properties at elevated temperatures for Alloy 718 bars, forgings, and billets.

Reference	Lot No.	Heat Treatment
67596	2	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67596	3	1 hr/1800 F, 8 hr/1325 F, 8 hr/1150 F
67602	20	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67602	21	1 hr/1750 F, 8 hr/1325 F
67614	78	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	79	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	80	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	81	1 hr/1700 F, 8 hr/1325 F, 18 hr/1150 F
67614	82	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	83	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	84	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	85	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	88	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	89	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	90	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	91	1 hr/1750 F, 8 hr/1325 F, 18 hr/1150 F
67614	99	1 hr/1750 F, 8 hr/1325 F, 10 hr/1150 F
67614	113	1 hr/1800 F, 10 hr/1400 F, 10 hr/1200 F
67657	9	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67657	10	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F
67657	11	1 hr/1750 F, 8 hr/1325 F, 8 hr/1150 F

Alloy 718
Castings



Tensile Strength

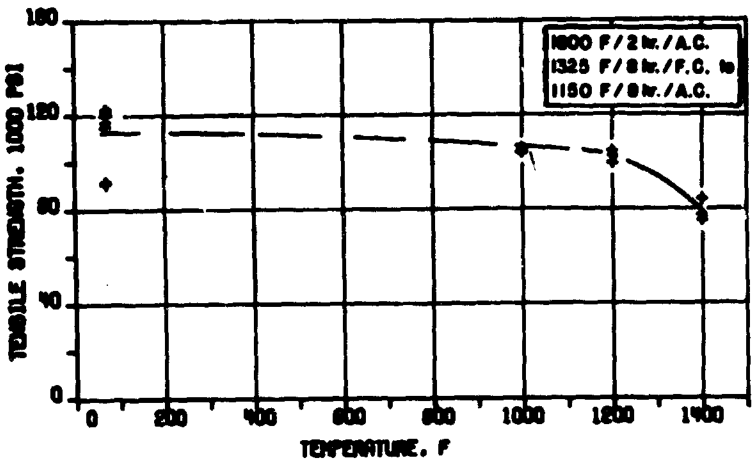


.2% Yield Strength

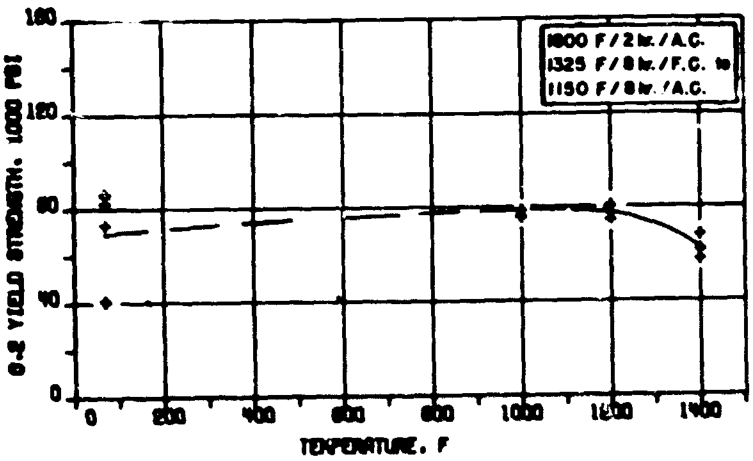
See Page IV-71 For Heat Treatment Conditions

DMIC data sheet

Base Material: Nickel
Metal or Alloy: Alloy 718
[illegible]



Tensile Strength



.2% Yield Strength

See Page IV-71 For Heat Treatment Conditions

DMIC data sheet

Base Metal: [illegible]
Name of Alloy: Alloy 713
Form: Castings
Condition: Various
Property Tested: Tensile [illegible]
p. 3 of 3

ACCESSION NUMBER 63610
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
70		73.2	115.2	17.6	25.0	
70		82.4	122.0	10.0	30.6	
70		85.7	120.4	10.0	31.2	

ACCESSION NUMBER 63610
LOT NUMBER 2

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
70		40.8	91.2	35.0	35.[illegible]	
70		40.8	91.4	29.0	29.7	
70		41.3	92.0	33.0	34.3	

ACCESSION NUMBER 63610
LOT NUMBER 3

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
70		82.1	115.2	20.0	23.0	
70		84.4	122.2	13.0	22.3	
70		84.6	117.2	12.0	10.9	
1000		76.0	104.4	21.0	30.6	
1000		75.6	104.2	22.0	34.5	
1000		70.0	106.0	21.0	33.2	
1200		70.6	99.0	17.9	33.2	
1200		77.4	103.0	17.0	31.0	
1200		80.4	100.0	13.0	31.9	
1400		68.5	84.4	10.0	16.7	
1400		57.6	77.4	12.5	33.0	
1400		[illegible]	75.2	16.0	24.5	

ACCESSION NUMBER 63673
LOT NUMBER 1

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
-423		125.2	190.2	3.0	7.9	L
-423		127.6	159.2	6.0	12.3	L
-320		122.3	170.3	4.0	4.9	L
-320		110.2	[illegible]	4.9	4.0	L
-320		122.3	143.5	6.0	6.0	L
-110		107.3	175.0	7.0	7.6	L
-110		106.2	175.2	6.0	5.5	L
80		100.0	123.5	[illegible]	0.3	L
80		107.2	117.2	6.0	6.3	L
85		99.2	119.3	10.0	10.0	L
80		110.5	120.6	7.0	7.0	L

ACCESSION NUMBER 67613
LOT NUMBER 34

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		121.6	147.9	13.9		

ACCESSION NUMBER 67613
LOT NUMBER 35

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		123.6	144.2	14.6		

ACCESSION NUMBER 67613
LOT NUMBER 36

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		114.2	141.6	16.2	20.6	

ACCESSION NUMBER 67613
LOT NUMBER 37

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		100.3	140.0	15.0	21.4	

ACCESSION NUMBER 67613
LOT NUMBER 38

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		90.5	117.2	21.2	30.3	
75		90.4	124.5	10.2	25.3	
75		94.7	120.2	21.1		

ACCESSION NUMBER 67613
LOT NUMBER 39

SHORT-TIME TENSILE PROPERTIES

TEMP F	YIELD STRENGTH 0.02 PC 1000 PSI	YIELD STRENGTH 0.2 PC 1000 PSI	TENSILE STRENGTH 1000 PSI	ELONG PER CENT	R.A. PER CENT	TEST MED
75		97.3	134.0	11.6	13.9	

Tensile properties at cryogenic, room, and elevated temperatures for Alloy 713 castings.

Reference	Lot No.	Heat Treatment
63610	1	As cast
63610	2	1 hr 1800 F
63610	3	[illegible]
63673	1	[illegible]
67613	34	Vacuum Melted, [illegible]
67613	35	Vacuum Melted, [illegible]
67613	36	Vacuum Melted, [illegible]
67613	37	Vacuum Melted, [illegible]
67613	38	Vacuum Melted, [illegible]
67613	39	Vacuum Melted, [illegible]

Room-temperature compression data for one heat of cast Alloy 718 are presented below.

Condition	0.2% Offset Compressive Yield Strength, ksi	Compressive Ultimate Strength, ksi[a]	E_c, 10^6 psi
Solution Treated	350	Not detected	6.3
Solution Treated	413	3800	5.8
Aged	840	3660	6.4
Aged	871	3210	6.8

Heat 65-506

Solution Treated: 1800 F/2 hrs/Air Cool
Aged: 1325 F/8 hrs/Furnace Cool to 1150 F-hold 8 hrs-Air Cool

[a]Based upon load at failure and original cross sectional area. All failures were ductile shear type.

Ref: 63618

DMIC

Cryogenic, room, and elevated temperature charpy impact data for one heat of Alloy 718 are presented below:

Condition	Test Temp., F	Impact Strength, ft-lb
Aged	-40	10.0
Aged	-40	13.2
Aged	-40	12.6
Aged	-40	11.2
Aged	R.T.	12.7
Aged	R.T.	13.7
Aged	R.T.	15.7
Aged	R.T.	13.6
Aged	1200	18.6
Aged	1200	16.8
Aged	1200	19.8
Aged	1200	18.5

Heat 65-506

Solution Treated: 1800 F/2 hrs, A.C.
Aged: 1325 F/8 hrs, Furnace cooled to 1150 F, hold for 8 hrs., A.C.

Ref· 63618

Cryogenic, room, and elevated temperature fracture-toughness data for one heat of cast Alloy 718 are presented below. Charpy impact test specimens were pre-cracked in bending fatigue to an average depth of 0.2 inches at the root of the notch following heat treatment:

Condition	Test Temp., F	Energy to Fracture, ft - lb	G, in-lb/in^2
Aged	-40	6.6	733
Aged	-40	6.5	666
Aged	-40	6.8	752
Aged	-40	6.5	709
Aged	R.T.	8.0	840
Aged	R.T.	7.8	828
Aged	R.T.	5.7	640
Aged	R.T.	5.8	595
Aged	1200	10.7	1182
Aged	1200	12.7	1268
Aged	1200	9.3	1046
Aged	1200	10.6	1173

Heat 65-506

Solution Treated: 1800 F/2 hrs/A.C.
Aged: 1325 F/8 hrs/furnace cooled to 1150 F -- held for 8 hrs/A.C.

Ref: 63618

DMIC data sheet

Thermal fatigue data for one heat of cast Alloy 718 are presented below.

Condition	Temp. Cycle - F[a]	Cycles to Failure	Heating Compressive Stress, ksi	Cooling Tensile Stress, ksi
Aged	300-1400	*	920	762
Aged	300-1400	771	788	920
Aged	300-1400	387	866	893
Aged	300-1200	*	599	827
Aged	300-1200	*	1100	368

* Test discontinued after 1000 cycles without failure.

Heat 65-506

Solution Treated: 1800 F/2 hrs/A.C.
Aged: 1325 F/8 hrs/Furnace cooled to 1150 F -- held for 8 hrs/A.C.

[a] Heating time 0.5 minutes; cooling time, 2.5 minutes.

Ref: 63618

DMIC **data sheet**

Base Material: Nickel

Metal or Alloy: Alloy 718

Form: Castings

Condition: Aged

Alloy Data: Creep and rupture properties

ACCESSION NUMBER 63618
LOT NUMBER 3

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1200	68.0	67.6R	.0018		4.0	4.0	
1300	72.5	9.3R	.105		4.0	3.2	
1300	60.0	109.6R	.01		7.0	6.3	

ACCESSION NUMBER 63618
LOT NUMBER 4

ORIGINAL CREEP AND RUPTURE DATA

TEMP. F	STRESS 1000 PSI	DURATION HOURS	MIN RATE PER CENT PER HOUR	TOTAL CREEP PER CENT	RUPTURE EL PER CENT	RUPTURE RA PER CENT	HARD AFTER TEST
1300	72.5	9.8R	.054		1.0	3.2	

Reference	Lot No.	Heat Treatment
63618	3	2 hr/1800 F, 8 hr/1325 F, 8 hr/1150 F
63618	4	2 hr/1900 F, 8 hr/1325 F, 8 hr/1150 F

V. APPENDIX

Specifications

As was indicated in the sections covering the metallography and heat treatment of Alloy 718, both the composition and the heat treatment of this alloy tend to differ according to the intended application. It is for this reason that the applicable specifications can usually be identified as pertaining to creep-rupture or short-time applications. The "creep-rupture" specifications are usually preferred for jet-engine applications, while the "short-time" specifications cover material for pressure vessels and for applications involving relatively short exposures at elevated temperatures.

Alloy 718 is covered by eight Aerospace Material Specifications, which are listed below. In addition, it is covered by a number of proprietary specifications, some of which are included in the table of chemical compositions on the following page.

Aerospace Material Specifications for Alloy 718

Specification	Type of Product	Application
AMS 5383	Investment Castings	Creep-rupture
AMS 5589	Tubing	Creep-rupture
AMS 5590	Tubing	Short-time
AMS 5596	Sheet, Strip, Plate	Creep-rupture
AMS 5597	Sheet, Strip, Plate	Short-time
AMS 5662, 5663	Bars, forgings	Creep-rupture
AMS 5664	Bars, forgings	Short-time

Specifications

CHEMICAL COMPOSITION OF ALLOY 718 ACCORDING TO VARIOUS SPECIFICATIONS

Specification Identification	Company	Amount Specified(a), percent								
		Cb + Ta	Ti	Al	B	C	Si (max)	Mn (max)	S (max)	Cu (max)
AMS 5596A	SAE	5.00-5.50	0.65-1.15	0.40-0.80	0.002-0.006	0.03-0.10	0.35	0.35	0.015	0.10
AMS 5597	SAE	4.75-5.50	0.65-1.15	0.20-0.80	0.006 max	0.08 max	0.35	0.35	0.015	0.10
AMS 5663	SAE	4.75-5.50	0.65-1.15	0.20-0.80	0.006 max	0.08 max	0.35	0.35	0.015	0.10
AMS 5664	SAE	4.75-5.50	0.65-1.15	0.20-0.80	0.006 max	0.08 max	0.35	0.35	0.015	0.10
AGC-44152	Aerojet-General	4.75-5.5	0.65-1.40	0.10-0.80	0.001-0.010	0.10 max	0.45	0.45	0.015	0.30
EMS 580F	AiResearch Manufacturing Company	4.75-5.50	0.7-1.4	0.2-0.7	0.006 max	0.08 max	0.45	0.40	0.015	0.30
EMS 581D	AiResearch Manufacturing Company	4.75-5.50	0.7-1.4	0.2-0.8	0.006 max	0.08 max	0.45	0.40	0.015	0.30
B50T69-S6	General Electric Company, Large Jet Engine Department	4.75-5.50	0.70-1.40	0.20-0.80	0.002-0.010	0.10 max	0.45	0.35	0.03	0.75
C50T79(S1)	General Electric Company, Large Jet Engine Department	5.00-5.50	0.65-1.15	0.40-0.80	0.002-0.010	0.10 max	0.40	0.35	0.03	--
RB0170-101	North American Aviation-Rocketdyne	5.00-5.50	0.85-1.15	0.40-0.70	0.006 max	0.06 max	0.35	0.35	0.015	0.30
RB0170-038"E"	North American Aviation-Rocketdyne	4.75-5.50	0.70-1.40	0.20-0.80	0.006	0.10 max	0.45	0.40	0.015	0.30
RB0170-039	North American Aviation-Rocketdyne	4.75-5.50	0.65-1.15	0.35-0.85	0.006 max	0.03-0.10	0.45	0.40	0.015	0.15
PWA 1009-C	Pratt and Whitney Aircraft	5.00-5.50	0.65-1.15	0.40-0.80	0.006 max	0.03-0.10	0.35	0.35	0.015	0.10
9-222(A)	Solar	4.75-5.50	0.70-1.2	0.20-0.80	0.001-0.007	0.03-0.10	0.45	0.35	0.015	0.30
9-221(A)	Solar	4.75-5.50	0.70-1.2	0.20-0.80	0.001-0.007	0.03-0.10	0.45	0.35	0.015	0.30

(a) In addition to the elements shown in the table, all specifications call for the following: Co, 1.00 max; Ni + Co, 50.00-55.00; Cr, 17.00-21.00; Mo, 2.80-3.30; Fe, balance. When specified, P is 0.015 maximum. Ta is listed in RB0170-101 as 0.50 max and in B50T69-S6 as 1.00 max.

Chemical Compositions for Data Sheets in Section IV

Reference	Lot	Chemical Composition NI	CO	CR	MO	FE*	C	B	TI	AL	CB
50031	1	(Composition not reported.)									
51792	1										
	2										
	3										
	4										
	5										
55290	1	52.29		18.80	3.12	18.84	.04		.85	.35	5.15
61323	1	52.00	.06	18.68	3.07	19.16	.04	.002	1.01	.33	5.19
	2	52.00	.06	18.68	3.07	19.16	.04	.002	1.01	.33	5.19
	3	52.00	.06	18.68	3.07	19.16	.04	.002	1.01	.33	5.19
63618	1										
	2										
	3										
	4										
63649	1	BAL.		18.59	3.07	18.95	.04	.003	.81	.27	
63742	1										
63743	1	52.83		19.41	3.05		.08	.007	.91	.63	
65177	6	53.36		18.92	3.12	17.34	.05		.98	.34	5.23
	7	53.36		18.92	3.12	17.34	.05		.98	.34	5.23
	8	53.45		17.73	3.22	18.96	.05		.64	.45	4.88
	9	53.45		17.73	3.22	18.96	.05		.64	.45	4.88
	11	52.29		18.80	3.12	18.84	.04		.85	.35	5.15
	13	52.29		18.80	3.12	18.84	.04		.85	.35	5.15
	14	52.16		19.24	3.10	18.44	.03		.84	.43	5.16
	15	52.16		19.24	3.10	18.44	.03		.84	.43	5.16
	16	52.16		19.24	3.10	18.44	.03		.84	.43	5.16
67595	11	52.00		19.00	3.00		.08		.90	.60	
	12	52.00		19.00	3.00		.08		.90	.60	
67596	1	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	2	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	3	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	4	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25

* Balance, if not reported.

Reference	Lot	NI	CO	CR	MO	FE*	C	B	TI	AL	CB
					Chemical Composition						
67596	5	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	6	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	7	52.83	.11	18.78	3.00		.03	.003	1.06	.60	5.25
	8	52.35	.07	19.46	3.01		.036	.004	.99	.43	5.30
	9	52.35	.07	19.46	3.01		.036	.004	.99	.43	5.30
67602	20	53.23	.55	18.75	2.99		.07	.001	.94	.64	
	21	56.61		18.24	2.81	16.43	.06		.77	.49	
	22	53.28		18.00	3.20		.09	.004	.83	.56	
67609	39	52.10		19.89	2.97		.06	.006	.81	.60	5.24
	40	52.00		19.80	3.00		.08	.005	.83	.55	5.20
	41	51.70		19.80	3.00		.07	.004	.80	.71	5.20
	42	50.65		20.00	2.92		.09	.005	.82	.57	4.77
67613	24	51.30		19.70	3.40		.05	.006	1.14	.46	5.60
	25	51.70		20.30	3.10		.08	.004	.85	.74	4.88
	26	53.40		19.00	3.36		.05	.003	1.20	.48	4.91
	27	54.00		18.85	3.23		.04		1.11	.52	5.27
	28	52.30		18.70	3.28		.05	.002	1.10	.40	4.96
	29	54.52		18.20	2.95		.05	.006	.85	.68	5.58
	30	54.20		18.60	2.80		.02	.006	1.07	.48	5.03
	31	51.70		19.80	2.95		.06	.003	.69	.56	5.15
	32	51.70		18.30	3.00		.03	.004	.70	.48	5.05
	33	55.00		18.70	3.25		.06	.006	.93	.40	5.27
	34	53.60		18.80	3.14		.06		.89	.55	4.76
	35	53.30		18.50	3.12		.08		.96	.50	4.98
	36	54.60		18.10	3.32		.06		.95	.64	5.08
	37	53.20		18.40	2.40		.07		.73	.53	4.72
	38	52.80		19.00	3.10		.03		.60	.37	4.50
	39	51.70		18.40	3.78		.04		.83	.58	5.05
67614	78	52.20	.10	18.80	3.00		.033	.004	.90	.50	5.25
	79	52.00	.18	18.70	3.07		.038	.004	.93	.46	5.08
	80	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	81	52.40	.42	19.00	3.02		.043	.004	.98	.44	

* Balance, if not reported.

Reference	Lot	NI	CO	CR	MO	FE*	C	B	TI	AL	CB
					Chemical Composition						
67614	82	52.20	.10	18.80	3.00		.033	.004	.90	.50	5.25
	83	52.20	.10	18.80	3.00		.033	.004	.90	.50	
	84	52.20	.10	18.80	3.00		.033	.004	.90	.50	
	85	52.00	.18	18.70	3.07		.038	.004	.93	.46	5.08
	86	51.80	.10	18.70	3.00		.033	.003	.83	.47	5.20
	87	51.80	.10	18.50	2.94		.048	.005	1.00	.54	5.12
	88	51.80	.10	18.50	2.94		.048	.005	1.00	.54	5.12
	89	51.80	.10	18.50	2.94		.048	.005	1.00	.54	5.12
	90	52.00	.54	19.00	3.00		.043	.005	1.00	.48	5.20
	91	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	92	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	93	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	94	52.40	.20	18.50	3.06		.043	.003	.940	.45	5.20
	95	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	96	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	97	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	98	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	99	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	100	51.80	.10	18.50	2.94		.048	.005	1.00	.54	5.12
	101	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	102	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	103	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	104	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	105	51.80	.10	18.70	3.00		.033	.003	.83	.47	5.20
	106	51.80	.10	18.70	3.000		.033	.003	.83	.47	5.20
	107	52.00	.54	19.00	3.00		.043	.005	1.00	.48	5.20
	108	52.00	.54	19.00	3.00		.043	.005	1.00	.48	5.20
	109	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20
	110	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	111	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	112	52.40	.20	18.50	3.06		.043	.003	.94	.45	5.20
	113	52.40	.42	19.00	3.02		.043	.004	.98	.44	5.20

* Balance, if not reported

Reference	Lot	Chemical Composition									
		NI	CO	CR	MO	FE *	C	B	TI	AL	CB
67657	9	52.07		19.33	3.03		.049	.004	.87	.60	
	10	52.34		19.15	3.01		.04	.004	.84	.57	
	11	52.11		19.31	2.98		.045	.004	.87	.61	
63673	1	54.08		18.97	2.91		.04		.80	.84	

* Balance, if not reported.

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List of Symbols

Symbol[a]	Description
TUS (F_{tu})	Tensile ultimate strength
TYS (F_{ty})	Tensile yield strength (0.2% offset)
CYS (F_{cy})	Compressive yield strength
SUS (F_{su})	Shear ultimate strength
BUS (F_{bru})	Bearing ultimate strength
BYS (F_{bry})	Bearing yield strength
e	Elongation
E	Modulus of elasticity in tension
E_c	Modulus of elasticity in compression
G	Modulus of elasticity in shear
μ	Poisson's ratio
ρ	Density
C	Specific heat
K	Thermal conductivity
α	Coefficient of thermal expansion
K_t	Stress-concentration factor
K_{Ic}	Critical stress-intensity factor
e/D	Edge/distance ratio (bearing data)
A	Ratio of alternating stress to mean stress (fatigue)
R	Ratio of maximum stress to minimum stress (fatigue)

[a] Symbols shown in parentheses indicate minimum values used in design.

Data Basis for "Design" Properties

Tables of "design" mechanical and physical properties in this document indicate a coded basis for the values presented therein. This code employs the letters A, B, and S, which are defined below, together with explanatory footnotes as required. The data basis indicated by this code is applicable to the following properties: F_{tu}, F_{ty}, F_{cy}, F_{su}, F_{bru}, F_{bry}, and e. It is not applicable to elastic or physical properties (E, E_c, G, μ, ω, C, K, and α), which are average properties, nor is a data basis applicable to individual test data, averages, or plots of these data.

The use of a data basis, together with the designation of data as "design properties", implies that the data have been reduced in some manner to minimum values, defined as follows:

A basis. The A mechanical-property value is the value above which at least 99 percent of the population of values is expected to fall, with a confidence of 95 percent.

B basis. The B mechanical-property value is the value above which at least 90 percent of the population of values is expected to fall, with a confidence of 95 percent.

S basis. The S mechanical-property value is the minimum value specified by the Federal Specification, Military Specification, or SAE Aerospace Material Specification listed for the material. For certain products heat-treated by the user, the S value may reflect a specified quality-control requirement.

Usually, only F_{tu} and F_{ty} in a specified testing direction are determined in such manner that they can be termed A or B values, in accordance with the definitions given above. Likewise, usually only F_{tu}, F_{ty}, and e are specified in the governing specifications and can be termed S values. However, ratioing procedures have been established by means of which other property values for F_{tu} and F_{ty}, and the same basis is used.

A more detailed description of data bases and the computational procedures used to determine design values is presented in AFML-TR-66-386 "MIL-HDBK-5 Guidelines for the Presentation of Data" (February 1967).

Constant-Life Diagrams (fatigue)

Fatigue-test data in this document are presented either in stress-lifetime (S-N) tables or curves or in constant-life diagrams, depending on the type of data that are available. Since the latter are not familiar to many readers, a brief description of their construction and use may be helpful.

Each constant-life diagram represents a composite, or "cross-plotting", of related S-N curves for several stress ratios. Initially, stress-lifetime data[a] are plotted as stress (usually maximum stress) versus lifetime (number of cycles, logarithmic scale). Individual plots are usually made for each set of test conditions (stress ratio, notch acuity, testing temperature) and product (product form, heat treatment, etc.). In addition, tensile data (at temperatures below that at which creep is significant) and creep-rupture data (at elevated temperatures) are employed as "fatigue" data for the limiting case where alternating stress is zero (A = 0, R = 1).

Within each plot a smooth curve is drawn to represent the mean of the plotted data. Then, from each related curve, differing only in stress ratio, stresses are selected corresponding to one or more arbitrary lifetimes. By convention, these lifetimes are in powers of 10 cycles (that is, 10^3, 10^4, etc.)[b]; within the temperature range at which creep occurs, the corresponding duration in hours is usually indicated parenthetically (duration = number of cycles/frequency).

On a constant-life diagram, these points are replotted, and smooth curves are drawn through the plotted points representing each lifetime.

The format used for these diagrams is that approved for use in Military Handbook 5. It represents a modified Goodman diagram, which has been rotated 45 degrees to permit horizontal and vertical scaling of maximum and minimum stress, respectively. Diagonal scaling is employed for alternating and mean stress, and different stress ratios are indicated by a series of straight lines radiating from the origin.

This diagram may be used in many ways. For example, to determine the maximum stress corresponding to a specified lifetime and stress ratio, one would find the intersection of the lifetime curve and the stress-ratio radian, then read the coordinates of this intercept on the maximum-stress scale on the left margin of the plot.

A more detailed description of constant-life diagrams may be found in AFML-TR-66-386, "MIL-HDBK-5 Guidelines for the Presentation of Data" (February 1967).

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a The term "lifetime" may be applied either to rupture, the attainment of 0.2 percent plastic strain, or other life criteria as desired.

b Within the lower temperature range, tensile data are presumed to be time-independent and a single value (TUS or TYS) is used for all lifetimes. Creep-rupture data are first converted to equivalent number of cycles at the frequency employed in conducting the fatigue tests (number of cycles, n = time/frequency).

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Battelle Memorial Institute Defense Metals Information Center 505 King Avenue, Columbus, Ohio 43201	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Nickel - Base Alloys / Alloy 718

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

DMIC Handbook

5. AUTHOR(S) (Last name, first name, initial)

Wagner, H.J., Burns, R.S., Carroll, T.E., and Simon, R.C.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1, 1968	112	62

8a. CONTRACT OR GRANT NO. F33615-68-C-1325	9a. ORIGINATOR'S REPORT NUMBER(S) None
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U.S. Air Force Materials Laboratory Research and Technology Division Wright-Patterson Air Force Base, Ohio

13. ABSTRACT

This handbook consists of five sections: (1) Metallurgy (2) Manufacturing Processes (3) Application Factors (4) Mechanical Properties and (5) Appendix. The first three sections are descriptive; the Mechanical Properties section presents design data and data on tensile-, fatigue-, impact-, creep-rupture-, and thermal-fatigue-properties for various mill forms.

DD FORM 1473

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Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Nickel Alloys (Alloy 718)						
Mechanical Properties						
Tensile properties						
Fatigue						
Creep						
Compressive properties						
Toughness						
Thermal stresses						
Metallurgy						
Metallography						
Melting						
Casting						
Corrosion						
Manufacturing Methods						
Metallurgy (continued)						
Machining						
Heat Treatment						
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